DISCOVERY

APRIL 1957 2/6

DISCOVERY

EDITOR: Anthony R. Michaelis, Ph.D., B.Sc. EDITORIAL OFFICE: 244 High Holborn, W.C.1. CHAncery 6518
SUBSCRIPTION, DISTRIBUTION AND BUSINESS COMMUNICATIONS TO: Jarrold & Sons Ltd, Norwich. Norwich 25261
ADVERTISEMENT OFFICE: Aldridge Press Ltd, 27 Chancery Lane, W.C.2. HOLborn 8655

APRIL 1957 **VOLUME XVIII** **NUMBER 4**

CONTENTS

The Cover picture shows the Pearly Nautilus. See p. 144.

VOC
OF
A mo
Flood
task i
in the
faced
dent u
ignora
the im
of a su
fewest
reader
the pr
in the
cing I
There
supple
been p
"The
Flood
words
science
A and
semi-sc
the sci
The
the au
This c
bulk o
of pop
will do
is all t
for car
it all t
vocabu
familia
can do
It is to
underst
panied
precise
an aut
happen
he inev
nical te
explain
to do t
printed
of man
as he c
used no
say noth
On p
cept an
This is

* Oliv
Birmingh

THE PROGRESS OF SCIENCE

VOCABULARY IN THE POPULARISATION OF SCIENCE

A monograph has recently been published by W. E. Flood,* the purpose of which is to help those whose task it is to popularise science. The need is expressed in the introduction in the following words: "We are faced with an anomaly; a community which is dependent upon science but whose members are singularly ignorant of science." Except for a short final chapter, the implication is that this need is best met by the choice of a suitable vocabulary, this being one that contains the fewest possible number of words unfamiliar to the lay reader. Three of the eight chapters give an account of the principles that guided W. E. Flood and M. P. West in the preparation of their "Explaining and Pronouncing Dictionary of Scientific and Technical Words". There are sundry tables of which some are merely supplements to lists of recommended words that have been published elsewhere. The final table is entitled "The Consolidated Popular-Science Vocabulary". Mr Flood claims, on p. 47, that the vocabulary of 2012 words gives a complete writing vocabulary for popular science. On p. 48 he refers to two more restricted lists, A and B, containing respectively essential scientific and semi-scientific words, and he says that these include all the scientific words which the author really needs.

The eighth and final chapter gives helpful advice to the author who would explain science to the layman. This chapter is wholly to be recommended, but if the bulk of the monograph is taken to heart by the author of popular science literature we do not know whether he will do more to enlighten or to mislead his readers. It is all to the good to make the author aware of the need for care and consistency in his use of technical terms; it it all to the good to encourage him to consider the vocabulary with which his prospective readers are familiar. But it may be mischievous to suggest that he can do this best by looking up terms in a vocabulary. It is too much to expect every reader of a periodical to understand every article. Progress, moreover, is accompanied by new concepts and these can only be expressed precisely with the help of new technical terms. To limit an author's vocabulary is to limit his range. What happens to the lay reader of a technical article is that he inevitably encounters a number of unfamiliar technical terms. He is helped when the author defines and explains some of them, but he cannot expect the author to do this for every term that does not occur in some printed vocabulary. The reader will learn the meaning of many of the unfamiliar terms from the context, just as he did in infancy. If when talking to a baby one used no words with which it was not familiar, one would say nothing at all to it.

On p. 9, Mr Flood says, "But understanding a concept and knowing its name are not the same thing." This is quite true. But the converse is equally true. Many people know the name of a scientific concept and yet do not understand that concept. Force, energy, and power are examples. Yet energy is not shown in Table V as a highly scientific but as an ordinary non-scientific word. In a footnote on p. 9, "de-hydration" is given as an example where the layman understands the concept and does not know its name. The choice is unfortunate. The layman may know the concept for which the word is "drying", but "de-hydration" is not the same by any means. It implies, for instance, removal of water of crystallisation. As someone once said, "If I dry my socks I can put them on again; if I de-hydrate them they will disintegrate into a powder." Mr Flood says, on p. 47, "It is an important finding that it is possible to present science to the ordinary man within a surprisingly small vocabulary." Be it admitted that one should try to do this. It has also to be admitted that one must not carry the process too far. If one does, one will have to replace the word "present" in the above sentence by the word "mis-represent".

It is true, as is said on p. 17, that *vocabulary* is one of the obstacles to a layman's understanding of science, but an even bigger obstacle is the unfamiliarity of the *concepts*. A person whose training has been predominantly humanistic finds the greatest difficulty in entering the scientist's universe of discourse. The more familiar the words are that he meets there, the more likely are they to evoke the wrong associations; the word energy, for instance, almost invariably does this. Therefore the biggest task facing the author who would explain science to the layman is that of conveying concepts. If he succeeds in this, the layman will acquire the vocabulary as he reads. An author who appreciates this will obtain some help from Mr Flood's vocabulary, but this vocabulary must not be used for dodging the real hard work of exposition.

* Oliver and Boyd, Edinburgh, 1957, for the University of Birmingham Institute of Education, 121 pp., 6*s*.

PHILOSOPHY OF TECHNICAL PROGRESS

The recent Government White Paper on Technical Education in Great Britain has drawn the attention of the nation to the need of a great expansion of this form of education and to the grave shortage of scientists and technologists. The White Paper has described the Government's plans for increasing the extent of university science teaching, engineering and research, and envisages the development of the technical colleges in the country, and the up-grading of a number of institutions into colleges of advanced technology.

In a more recent survey, the Minister of Labour and National Service,* and the Advisory Council on Scientific Policy, reports on the number and distribution of scientists and engineers now employed in Great Britain, and presents a study of the likely trend in the future demand of these highly trained men and women. The purpose of the Advisory Council is to facilitate forward planning, by giving an indication of the requirements

* "Scientific and Engineering Manpower in Great Britain", H.M. Stationery Office 1956.

likely to arise on the most reasonable assumptions that can be made about the future. For the purpose of convenience the Committee of Scientific Man Power reverted to the two terms "scientist" and "engineer" to cover the basic sciences on the one hand, and the applied sciences in the engineering field on the other. The term "scientist", therefore, was made to refer to people with graduate or equal qualification in one or more of the basic sciences, while the term "engineer" concerned people with a university degree or its equivalent in the engineering groups. Later on we shall re-introduce the use of the terms technology and technologist on account of their wider aspects in the new fields of modern science and engineering.

The committee set themselves the task of obtaining some idea of the gross flow of people, qualified in pure and applied science, that would be compatible with a 1966 employment figure of the order of 220,000. Their researches suggest that the number of people qualifying each year in science and engineering would need to increase from about 10,000 in 1954–5 to about 20,000 in 1970—an increase of about 100%. The committee states that there are already signs of an increase in student numbers, and it may well be that the flow will rise to 12,000 in 1958–9, but if we make reasonable allowances for emigration, overseas students, etc., the average annual flow of students in the following five years would have to reach 16,000 if the stock of scientists and engineers is to increase to 220,000 by 1966. This, as is pointed out, would indeed be a remarkable educational achievement.

It is very evident from these figures that while this building-up process is in being, there will be a shortage of scientific manpower for some years to come. It is therefore of paramount importance that steps should be taken not only to maintain but to increase the flow of suitably qualified students entering industry and the teaching profession. It is, moreover, most urgent that our country should produce the men and women who can control the pace and direction of scientific effort. In this reorientation of effort, the principal rôles will be played by the pure scientist, the technologist and the technician.

Perhaps the most important member of this trio of technical workers is the *pure scientist*. He it is who wrests from Nature her secrets, and plans the future of discovery. He it is who discovers the laws through which Nature is operating and discerns the conditions in which these laws will prove effective.

Research is proceeding at a great pace throughout the whole world. It is therefore of great importance that his discoveries shall be assimilated and examined before these next steps are taken and beginnings are made in the design of mechanisms and installations which embody the principles already discovered by the pure scientist. This is the duty of the *technologist*. The technologist is essentially a man with a deep knowledge of his own subject, and a wide acquaintance with the techniques and advances in allied branches of science and engineering. It is he who uses this knowledge in the creation of new mechanisms and processes, and in the construction of factories and power stations often of revolutionary design from research already carried out. Entirely new techniques may require to be devised, and further research of a more fundamental nature may be undertaken.

It is evident that in this harnessing of new and immense sources of energy, and in the development of new processes in already well-established fields, the finest minds the country possesses will be needed. Your very good technologist is somewhat of a "rare bird", one difficult to catch and retain, for the ways along which he and his collaborators may speed are still largely uncharted. He is the type of man who, Sir John Cockcroft has stated, is sorely needed in his atomic energy projects, and this opinion is echoed by most prominent industrialists.

Moreover, in addition to purely technical responsibilities, the technologist will be active with advice regarding new ways of living and how we, as citizens, are to adapt ourselves to fresh concepts of leisure.

The technologists may well be termed the philosophers of modern science.

But the technologist cannot work without the *technician* as his helpmate. The factories and machinery having been designed, the techniques developed, the installations will not run of themselves. It is the technician who, in the broader sense, "makes the wheels go round". The technician has not the wide and deep knowledge and experience of the technologist. He has received his training in the factory and technical school in a much narrower field of science, and his particular job is to carry out the techniques and processes brought into being by the technologist, or to work under his direction within definite limits. In this smaller world the technician often acquires great skill and may evince much originality and dexterity on the more practical side. Without him our great factories must close down; and the opportunity to broaden his knowledge and increase his mental equipment is therefore one of the great missions of our large and important technical institutions. There should, above all, be a very wide link-up between the training of our technologists and that of our technicians, so that opportunity is provided for technicians of proved ability ultimately to qualify for work in the larger sphere of technology.

EXPORTING ATOMIC REACTORS

The fair vision that atomic energy would make deserts live, make it possible to work minerals in and out-of-the-way places and generally lift the standard of living of people in under-developed countries is still with us, and partly explains why there is at present so much interest in the export of atomic power stations. Nobody is blind to the commercial advantages that will accrue to the nation that first establishes a commanding lead in this field; so that speculation about which country is going to be successful in this new business has been given more tangible form by the announcement, a few weeks ago, that a British engineering firm has made an agreement with an American nuclear engineering firm in order to put on the market comparatively small

lutionary
irely new
l further
be under-

new and
pment of
elds, the
ed. Your
re bird",
ays along
are still
Sir John
s atomic
by most

responsi-
h advice
s citizens,
re.
he philo-

the *tech-*
nachinery
oped, the
the tech-
wheels go
and deep
He has
cal school
particular
s brought
under his
ler world
ay evince
tical side.
own; and
d increase
the great
al institu-
le link-up
d that of
vided for
ualify for

ke deserts
out-of-the-
living of
th us, and
ch interest
Nobody is
accrue to
ng lead in
country is
has been
ent, a few
s made an
ering firm
ely small

LOOKING AT BIRDS

Three examples of outstanding bird photographs to be shown at an Exhibition at Kodak House, Kingsway, London, during April. They were taken by Eric Hosking, F.R.P.S., the well-known bird photographer, by means of high-speed flash photography. The equipment was specially built by Dr P. S. H. Henry of Manchester. *Top left*: Hoopoe brings a lizard to its nest in a beehive built of Cork Oak. South Spain. *Top right*: Golden Oriole feeding a Silver Y moth to its young. The nest is beautifully slung under the branch of an Alder tree. Holland. *Below*: Golden Eagle photographed in 1956 at its eyrie in the Scottish Highlands.

atomic power stations of an American design. It is only natural to look for some comparison of the prospects of this reactor and those which British firms are able to supply.

One of the imponderables here is a technical one. Because the development of atomic energy in Britain has gone on rather different lines from those which the Americans have followed, the reactors which American firms are ready to sell abroad serve purposes which are rather different from those of the Calder Hall pattern. The latter are huge structures which are only competitive in Britain when they are used to generate individually very large amounts of power. Each reactor in the first civil atomic power stations now being built in Britain will produce something like 150,000 kW. Later power stations are likely to have still greater outputs. But even now fifteen atomic reactors of the British pattern would be able to supply the whole of the present consumption of electricity in India, for example.

Clearly it would be somewhat difficult to make full use of reactors of this kind in all but a few areas in India, and the difficulties in some other countries overseas would be still greater. A measure of the difficulty is provided by various surveys which have been carried out of the electricity generators which are at present in use in the Middle East. It appears that a generating set of 10,000 kW. capacity is a very large one. 1000 kW. sets, driven by diesel engines, are common, and these tend to be used for roughly half of each day to produce electricity at a cost which may be anything from three to four times that which is acceptable in Britain. While it seems that there is some latitude in the Calder Hall design, and that it would be possible to build atomic power stations of this type which have much smaller generating capacities, it is inconceivable that the design could be adapted to power stations producing less than 50,000 kW.; at that point the capital cost of each unit of generating capacity would be so high that diesel generating sets would be far preferable on economic grounds.

It is for this reason that, for the time being, British hopes in the atomic export market are pinned to parts of the world which can make use of large amounts of power from single power stations. These include all the industrialised nations of Western Europe, together with countries like Japan. Then there is the possibility that it might prove economic to install nuclear power stations near large mining and smelting areas, such as those in Rhodesia or South Africa, where there is scope for bulk use of electricity. But this is nothing like the whole of the world.

By an odd chance, American reactors promise to be suitable where British ones are not. The development of atomic energy in the United States has been dominated by the fact that enriched uranium was available in good supply soon after the war. This has meant that the Americans have been free to design nuclear reactors which make use of enriched uranium as a fuel. While these have not been developed to the point at which electricity from them costs as little as that from the first British stations, they have the characteristic that each unit of generating capacity costs less to install. This means that reactors which the Americans can now sell, modelled on the prime mover of the submarine "Nautilus", are economically more suitable for intermittent use and for small power stations than are the British reactors.

Thus it is that the United States at present has an advantage in that part of their potential export market which Britain cannot serve. How far this can be exploited remains to be seen. It may turn out that smaller countries will be unwilling to commit themselves to the use of American enriched uranium as fuel. Alternatively they may feel that until they have trained technologists of their own, it would be better to rely on the considerably simpler diesel generating sets which are so commonly installed in the Middle East.

Meanwhile research and the development of different kinds of atomic reactors is not at a standstill in Britain. The inspiration of this, at any rate as far as small reactors are concerned, is the need to develop engines for driving ships. In this field a reactor which differs from the American submarine reactors in that it uses an organic liquid instead of water and slightly enriched instead of highly enriched uranium as a fuel, is the most obvious candidate. Farther ahead is the prospect that a descendant of Calder Hall which uses a carbide of almost pure uranium-235 as a fuel will prove economic for small ship propulsion units and for land-based power stations with an output of 10,000 kW. or less. But these developments lie some distance ahead. In the meantime it must apparently be acknowledged that the export market for atomic power has been cut, by chance, into two, so that it will be some time before Britain and the United States come into direct competition.

THE FAILURE OF THE PARITY LAW

In our past experience the basic laws of nature have always been symmetrical between right screws and left screws and have given us no means for discriminating between them. This has long been known in molecular and atomic physics, where it has been found possible to produce spiral molecules in both left-handed and right-handed forms. This feature of the fundamental laws leads to a corresponding symmetry in elementary particles or systems of elementary particles, which is maintained through any nuclear reactions taking place between them. This symmetry is called "parity" by the physicists. The "parity law" or "law of conservation of parity" is then the statement that this symmetry property persists through all reactions which can occur in the system. For example, this parity law has been well established for the nuclear reactions which occur in the collisions between atomic nuclei.

However, in the last five years we have gained increasing knowledge of the K-mesons, mesons about one thousand times as massive as the electron, which were first discovered in cosmic radiation. Two of these K-mesons in particular, the τ-meson and the θ-meson, decay to π-mesons, the mesons of about 273 electron masses which are responsible for the main features of

nuclear forces. These two K-mesons have been found to have all their measureable properties the same, except that the τ-meson decays to three π-mesons, the θ-meson to two π-mesons. However, as the analysis of observations on these decay processes has shown, the three π-mesons from τ-meson decay have opposite parity-symmetry from the two π-mesons of θ-meson decay. Although it would be very natural to suppose that the τ-meson and θ-meson simply represent alternative modes of decay for a single K-meson, this is not possible if these decay processes follow the parity law, since this requires that all final systems to which decay of this K-meson could lead should have the same parity-symmetry.

Dr Lee of Columbia University and Dr Yang of the Institute for Advanced Studies at Princeton, working together at the Brookhaven laboratories last summer, inquired how much proof we really had that the parity law held true for the decay processes of elementary particles. They soon realised that none of the existing experiments gave any test of this belief, and so they pointed out a number of experiments which could provide suitable tests of the parity law for various elementary decay processes.

These experiments are concerned with the distribution in direction of the decay products from a spinning nuclear system which undergoes some decay process, such as β-decay. For a decaying system spinning with a right-hand rotation about its axis, the emission of a decay particle forwards along this axis of rotation defines a right screw, whereas emission backwards along this axis defines a left screw. Hence, if the decay process is governed by laws which do not distinguish between a right screw and a left screw—that is, if the parity law holds for the decay process—then the intensity of particles emitted in the forwards direction from the decay of this spinning system should be the same as for the particles emitted in the backwards direction.

This test has recently been made for the β-decay of cobalt 60 by Dr Wu of Columbia University, in a collaboration with the low-temperature group of the National Bureau of Standards at Washington. After being cooled down to a temperature of one-hundredth of a degree above absolute zero, a cobalt salt was subjected to a strong magnetic field which turned about 60% of the spinning cobalt nuclei to point their axes of rotation along the direction of this field. Dr Wu then found that about 50% more β-particles were emitted backwards than were emitted forwards, showing very clearly that the parity law fails for nuclear β-decay. Such a large effect implies that the β-decay process actually reverses the parity-symmetry about as often as it leaves the parity-symmetry unchanged.

Other situations which have been investigated are the π-meson decay, which gives a μ-meson (a meson of about 212 electron masses, well known in the cosmic radiation at sea-level, whose nuclear interaction is exceedingly weak) and a neutrino (a spinning, massless particle carrying energy, momentum, and angular momentum, first proposed to account for certain features of nuclear β-decay), and the subsequent β-decay of the μ-meson, which gives an electron and two neutrinos. Here again the parity law has been found to fail. This failure means that a μ-meson emitted from π-meson decay spins in a definite sense about its direction of motion; the β-decay of this μ-meson, after it has come to rest, shows again forwards-backwards asymmetry relative to this axis of spin, characteristic of failure of the parity law. This result was first established by Dr Lederman of Columbia University, and it has also been obtained by groups at Chicago, Göttingen, and Bristol, who have examined this succession of decay processes in nuclear emulsions.

Hence it is clear that at least three of the best-known decay processes for elementary particles involve violation of the parity law. It now seems highly probable that a parity violation is indeed the explanation of the τ-θ puzzle which gave rise to these investigations, although this is not finally proven. The physical cause for these violations of the parity law is not yet clear. One interesting possibility has been advanced by Lee and Yang, and independently by Dr Landau of Moscow University, which depends on the fact that the decay processes investigated in the above experiments each involve emission of one or more neutrinos. These workers have suggested that, relative to its direction of motion, a neutrino may be permitted only one sense of rotation, so that it defines a screw with a definite sense. This displays in a very transparent way how it may come about that the basic physical laws for these processes may contain reference to a definite sense of rotation. At present the experimental observations do not disagree with this interesting proposal. However, many other types of experiment must be carried out before this view can become established (or disproved).

This situation has naturally stimulated a tremendous activity amongst experimenters in many fields of nuclear and particle physics, and there has been a great flow of interesting speculations from theoretical physicists. An exciting period is clearly before us, as we come closer to some real understanding of the nature and rôle of a particle, the neutrino, which has always seemed rather mysterious.

HONEYCOMB STRUCTURES FOR AIRCRAFT

The hexagonal cell of the bee's honeycomb is about as economical of space as it could be. Man uses honeycomb, made of metal, for a different reason. He has adopted it as a structural material combining lightness with remarkable strength and rigidity. But he has retained the design and the name, and expressions like "metal sandwich", "cores", "cell dimensions", now have an established place in the vocabulary of the aircraft industry.

Metal honeycomb is being made on both sides of the Atlantic for use in aircraft structures such as wings, fuselages, tail planes, trailing edges, and flooring. When bonded on both sides to metal sheets, using a specially developed adhesive, it provides a sandwich panel capable of operating at skin stresses of 50,000 lb./sq. in. Its strength-to-weight ratio is much higher than that of a conventional stringer-reinforced aircraft panel.

Most of the pioneer work on man-made honeycomb for aircraft was carried out by a British firm before the war. At Duxford, near Cambridge, Dr Norman de Bruyne, a physicist from Trinity College, had set up some years previously a small laboratory and workshop to investigate new types of aircraft structure, with particular reference to expanded and foamed materials and the recently developed synthetic resin adhesives. British Patent 577,790 (1938) includes some interesting sketches of a honeycomb core, while in 1940 a paper written by Dr de Bruyne and two members of his staff at Aero Research Limited on "The stabilisation of a thin sheet by a continuous supporting medium" was published in the *Journal of the Royal Aeronautical Society*. It has remained the basis for numerous papers on the subject that have appeared from time to time.

The outstanding characteristic of sandwich structures is the way in which they combine great compressive strength with lightness, enabling high realised stresses to be obtained in the skins. As a core for such structures, several materials can be employed. Expanded plastics and end-grain balsa wood are examples, but metal honeycomb, usually made from aluminium foil, is superior in its consistent physical properties. It is, moreover, fire-proof, non-absorbent, and unaffected by variations in climatic conditions, and is immune to attack by insects, moulds, and vermin. It is easy to fabricate in panels of the required dimensions, and for varying needs it can be made in different strengths and densities.

Mechanical properties of aluminium honeycomb structures are governed by several variables, such as the thickness of foil employed, cell dimensions and the gauge and type of the facing skins. The ratio of core to panel thickness varies with functional requirements. If rigidity is the main criterion, the ratio of core thickness to panel thickness is normally about 0·95, but if bending properties are needed, as in floor panels, a heavier gauge skin can be used for the upper surface and a thinner skin below to accommodate the tensile load. Panels are always designed with the core located in the direction giving maximum shear strength, that is, for loading parallel to the cell axis.

The joining of skins to metal honeycomb cores originally presented difficulties: riveting was clearly out of the question and liquid adhesives would flow away from the areas of contact during bonding. A solution to this problem was provided in a development of "Redux" adhesive, already in general use for bonding metal to metal in load-bearing aircraft structures. "Redux", hitherto used as a two-component system of liquid and powder (and still normally employed in this form for conventional structures) was incorporated in a glass-cloth carrier to provide an adhesive film. The process of building honeycomb core into a sandwich panel now consists of placing a sheet of "Redux" film on a metal facing sheet, then locating the honeycomb on the film, followed by a further sheet of "Redux" film, and finally the other facing sheet. The whole panel is then cured at 145–168°C at a pressure of 10–50 lb./sq. in. for half an hour. The process is carried out between the platens of a suitable press, on a steam-heated table by using a rubber blanket under vacuum pressure, or in an autoclave.

Honeycomb cores can be made into panels of double curvature, and inserts of wood or almost any other desired material can be made to accommodate bolts, screws, or other local attachments. So far, their uses have been almost exclusively in aircraft, but we may soon expect to see developments involving honeycomb core in boats, motor vehicles, and other industrial applications where lightness and strength, sometimes involving weight savings of 50–100%, can be most profitably exploited.

HYPNOSIS TODAY

Dr L. Goldie, Registrar, the Maudsley Hospital, London, writes the following note on hypnosis today.

There has been a waxing and waning of public and scientific interest in hypnosis. It is a controversial subject, and with surprising resilience has always returned to prominence after periods of decline. To appreciate the vicissitudes it has undergone would be to sojourn too long in its historical past, edifying and humbling though that may be for those who count themselves "scientific". This history is littered with the names of those observers, often astute and reliable, who were persecuted and often ostracised by their contemporaries for their pains in transmitting to others their observations of hypnotic phenomena.

One difficulty has always been that some sort of procedure for inducing hypnosis must be carried out before the investigations begin. Though hypnotists could describe various manifestations, they could not transmit to others any technique for an induction process which others could follow to produce the same results, and this is the very essence of scientific procedure. In the main, the very absence of a rational explanation of the phenomena prevented this. Various writers quoted from their own experience of applying one or other of the ritualistic procedures. They gave, as if these were objective statistics, widely differing figures on susceptibility. Much modern work still suffers from these misconceptions. Induction is either not described, or the description is inadequate, so that often results and states have been compared that are in no way comparable.

Modern induction methods are not ritualistic. The process is adapted to the patient, and the therapist, like the swimming-instructor, gives directions that the pupil may choose to follow, using his physical and mental endowments with increasing efficiency in new ways. The success attained must be gauged by the ends desired by the patient; our aim may be simply to swim, and no amount of "instruction" will produce "Olympic form" if this is not our motive, regardless of our potentialities. All persons may be hypnotised, provided they have the capacity to co-operate. This capacity may vary from time to time in the same individual and depends upon his state and circumstances when hypnosis is attempted. This fact is illustrated by the fields in which hypnosis finds its most useful application at the present time. In

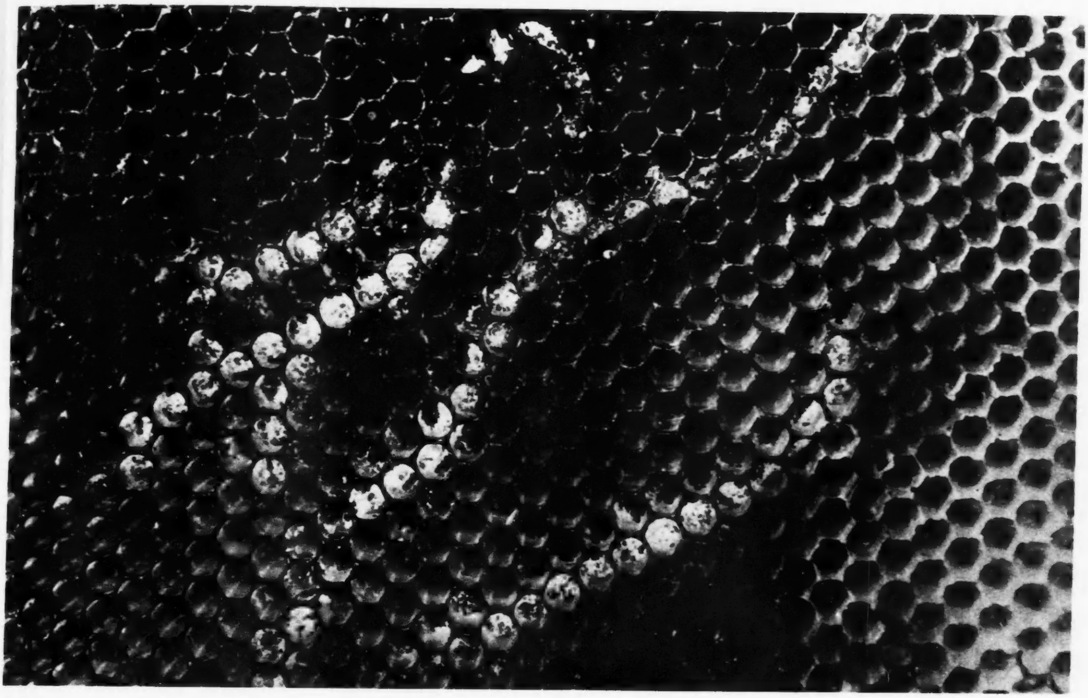
le press, on
anket under

ls of double
any other
odate bolts,
, their uses
out we may
honeycomb
istrial appli-
mes involv-
st profitably

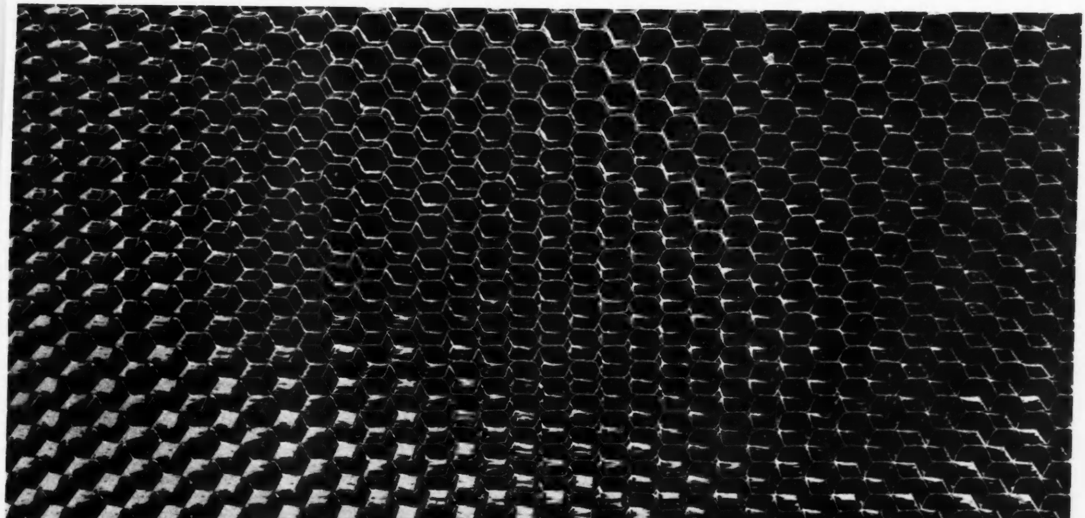
Hospital,
sis today.
public and
versial sub-
ys returned
appreciate
to sojourn
d humbling
themselves
e names of
who were
temporaries
eir observa-

sort of pro-
out before
tists could
ot transmit
ocess which
ts, and this
the main,
the pheno-
from their
e ritualistic
objective
lity. Much
onceptions.
scription is
have been

istic. The
rapist, like
t the pupil
nd mental
ways. The
desired by
n, and no
pic form"
entialities.
y have the
vary from
ends upon
attempted.
hypnosis
t time. In



Above: Honeycomb structure made by bees. *Below*: Honeycomb structure made by man.



the Casualty Department, it has been used with the greatest degree of success in those whose injuries have brought them to hospital immediately and in an excited state—in fractures and lacerations as opposed to "cold" conditions, such as abscesses.

Induction then consisted of showing the patient that he has already the wit and faculties to achieve the results he so much desires. The actual words used vary with the education, age, and experience of the patient. It is pointed out to him that it is his common experience to be so engrossed in a book that he does not hear someone call his name or realise that someone has come close, unknown to him. During treatment, as in his normal life, he may lose awareness of certain sensations even though the pathways to consciousness are unimpaired. Until the operator draws his attention to them the conversation and the thoughts that it evoked have made him unaware of the sensations of the shoes on his feet or the bed on which he lies or the clothes on his body. The patient is allowed to choose what method of distracting attention he most desires: he may imagine as vividly as he can going to sleep normally, visualising a scene, thinking of all his muscles individually and separately, relaxing. Where necessary, the patient is made aware of the fact that, as he carries out his task, the doctor will be using words that are all too inadequate to describe what is happening. For example, if the doctor uses the word "sleep" when a deeply relaxed state is desirable, he admits that this is an inappropriate word. Just as the patient cannot capture in words the exact instant when he goes from the waking state into normal sleep, his nightly experience, so it is as a makeshift that the doctor uses the word "sleep" in his suggestions.

Direct suggestion in former times was based on the assumption, often unconscious, that whatever develops in hypnosis derives from suggestions given, and the fact was disregarded that whatever develops is achieved by the patient and determined by the state and circumstance in which he finds himself. Unfortunately, some therapists have retarded progress by perpetuating these ideas. Hypnosis has, therefore, with the removal of these misconceptions, been applied most successfully when the patient's state could most readily be utilised in treatment using hypnosis. Hence, it has been used in the Casualty Department for the treatment of minor injuries, alleviating the pain of inoperable cancer, the management of burns, in dentistry, and in childbirth. It was also used in a Japanese prisoner-of-war camp where anaesthetics were not available for minor operations. It is being used in the treatment of those conditions where physical and mental inter-relationships are becoming increasingly obvious, such as skin diseases and the allergic disorders.

In psychiatry, as in other fields, the technique is adapted to the individual, his state, and the aims of therapy; though with more difficulty. Recognition of the differences between induction and the state which results has led to the investigation and utilisation in therapy of profound trance states not required in the instances described above. These states require special and skilled handling, and their use by the psychiatrically untrained can result in much psychological damage. It is for these reasons that psychiatrists in America have warned against the use of hypnosis in psychiatric conditions by psychiatrically untrained persons unskilled in psychotherapy. In the Soviet Union and America hypnosis is being used extensively in the management and treatment of many psychiatric conditions, but only to a negligible extent in England.

One bar to progress in this country had been the failure to recognise that hypnotism is not a treatment, though it has been both criticised and advocated as such. Hypnosis may be, like anaesthetics, of inestimable value to medicine, not because of any intrinsic curative properties but because many advances and forms of treatment are not practically possible without it. There are signs that this may especially be true of the relation of hypnosis to psychotherapy in the treatment of the neuroses—an important field where advances are urgently needed.

The study of hypnosis has led to new research problems requiring the co-operation of scientists from many disciplines, and we are coming nearer to answering many questions important for those who are sick in mind and body.

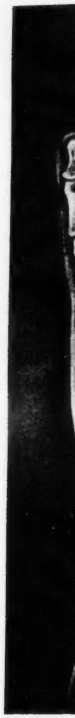
STATIC ELECTRICITY

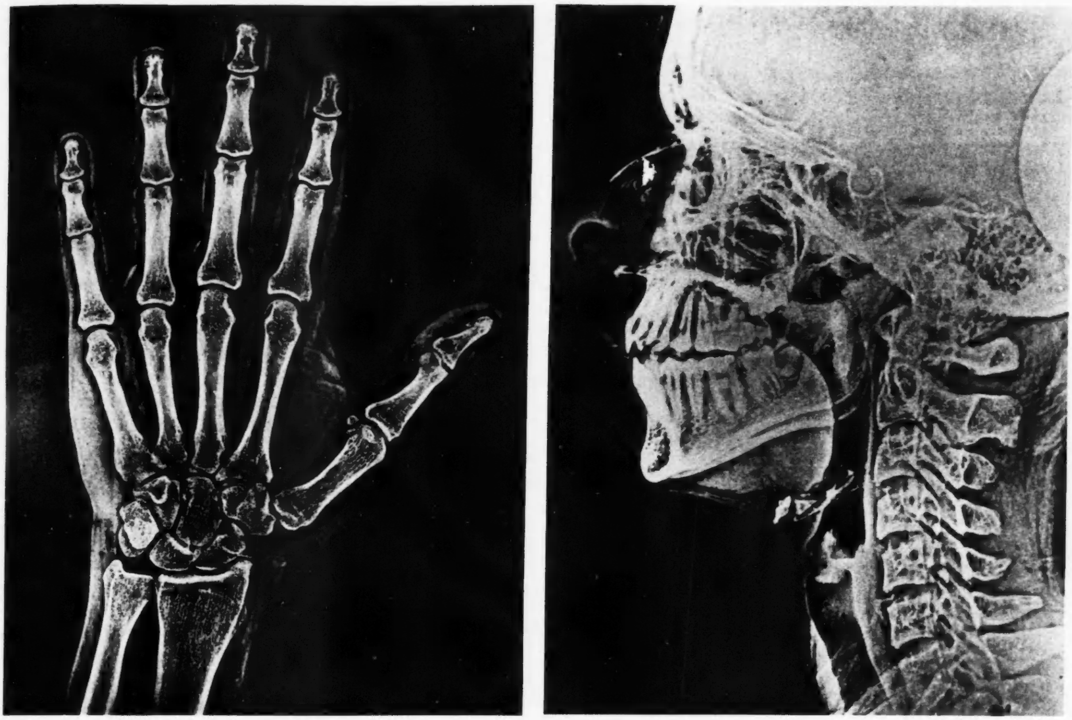
Static electricity, after suffering a long eclipse, has, during the last fifteen years, once again brought itself to the attention of research workers, not only as a nuisance encountered in handling rubber, natural and synthetic fibres, plastics and paper, but also as a potentially useful force.

Static electricity is the strongest known natural force, exceeding gravity by a factor of about 10^{39}, and it is only by a delicate balance between the forces of attraction and repulsion that all other forces in the universe are not overwhelmed by it. In these circumstances and in view of the fact that static electrical forces were among the first electrical phenomena to be investigated, it is all the more surprising that it has so long been neglected and that the study of its manifestations has been left to the upper forms of physics classes.

Today, however, thanks to the resurgence of interest which has taken place, a number of applications have been developed. Recently, for example, Rank Precision Industries announced that they were introducing "Xerography" to England. Xerography is a method of reproduction for text and illustration originated in the United States by C. F. Carlson. It makes use of electrostatic forces in much the same way that photography uses light, and is employed in preparing "masters" for offset lithography, in map-making, high-speed microfilm enlarging, facsimile reproduction, continuous-tone photography, and radiography. In this last application it has the double advantage of producing a positive picture, which is, at the same time, sharper in detail than its counterpart produced by conventional silver halide-x-ray processes.

The method of xerographic reproduction is broadly as follows: the object to be reproduced is projected upon





Xeroradiographs of (*left*) a human hand and (*right*) a human head, showing the considerable amount of detail which can be obtained by this process. (*Reproduced by courtesy of Rank Precision Industries Ltd.*)

a sheet of selenium metal which has a positive electrostatic charge. As the selenium holds its charge only when not exposed to light, the static electricity is dissipated save in those places where the dark parts of the original—the text or the lines of the illustration—are projected upon it. The plate with the image upon it is then cascaded with an ink consisting of powdered pigment and a thermosensitive binder, and this is retained in those places where the charge remains. A sheet of paper is placed over the plate and this is given a positive electrostatic charge so that it picks up some of the powdered ink. Finally, the paper is placed in a heat fuser for a short time where the ink is "fixed". Among the advantages of this process of reproduction is the extreme rapidity with which a positive copy can be made, as well as the fact that it is dry and that no negative is required.

Similar systems have been devised for the continuous coating of paper with pigment. The coating material, suspended as a cloud of dust in air, is charged electrically and deposited on the paper by means of strong electrostatic forces. After deposition the paper is heated to fix the colour upon it. The chief merit of this process again lies in speed, also that it is adaptable to different types of coatings, and that relatively high pigment loading on the paper can be obtained. In much the same way electrostatic forces have been used in the manufacture of emery-paper to overcome the problem of keeping the cutting edges of the abrasive uppermost.

Electrostatics have also been applied in spray-painting, resulting in large economies both of paint and of time. The workpieces to be painted are passed through a chamber in which particles of atomised paint are electrostatically charged. These workpieces are kept at earth-potential and therefore attract the paint particles evenly over the whole surface. By controlling the amount of paint, a coating of predetermined thickness can be given. This technique has been used in painting motor-car wheels, with the result that 50% of the paint normally used was saved. In the spraying of car bodies the time taken was cut down to $2\frac{1}{2}$ minutes. Welded steel tube sprayed in this way could be painted at the rate of 300 feet per minute, with large saving of paint. The process has been applied to giving clear and tinted varnishes to metal goods, the painting of wooden articles including tennis rackets, bicycles, and motor-cycles, and to giving decorative coatings of high quality.

Similarly, when the atomised particles of spray used in crop spraying are electrostatically charged, a much more even and complete coverage of the plants is obtained.

Recently, in both the United States and Great Britain,

there have been experiments in the use of electrostatic sparking plugs for internal-combustion engines. The advantages of this type of plug lie in the fact that no battery is required, but so far, although there has been some success in the experiments, they have not reached the stage at which they are a commercial possibility.

A NEW FRENCH OBSERVATORY

In a brochure published on August 10, 1956, the French *Centre National de la Recherche Scientifique* have announced details of their new observatory on the plateau of St Michel. This is situated in Haute-Provence, north of Marseilles and on the road between Avignon and Digne. It is very well equipped with a 120-cm. Newtonian and an 81-cm. Newtonian/Cassegrain reflector, a radiotelescope with a resolving power of five minutes of arc, apparatus for spectrophotometric research, and the use of electronic image converters. The emphasis has been on providing facilities for astrophysical research to fill the long-standing lacuna in France. To this end there will be installed during the present year an even larger reflecting telescope of 193 cm. aperture, fitted with a mirror by Couder and an equatorial mounting by Grubb and Parsons. A special feature of the Haute-Provence Observatory is that there shall be no permanent research staff, but that the facilities will be open, generally for periods of a few weeks at a time, to all French (and, indeed, also foreign) astronomers who stand in need of such facilities and apply for their use to the observatory directorate through the medium of their own observatory or other organisation. In this way it is felt that the equipment will be used to its maximum capacity and effect.

THE PEARLY NAUTILUS

Our cover this month shows a Pearly Nautilus shell cut open to expose the chambers shut off by successive concave partitions, the horny tubular "siphuncle" which connects the chambers, and the pearly inner layer. These handsome shells—up to six inches across, white with tawny stripes—are much more familiar than the living animals which form them. But *Nautilus*, shown in the sketch, is not so much rare as inaccessible, confined as it is to rather deep tropical waters in the western Pacific and Indian Oceans. Natives of the Philippines and Melanesian Islands catch it in plenty in large basket traps.

Though a spiral-shelled mollusc, *Nautilus* is not a snail but a cephalopod, related to the octopuses, squids, and cuttlefish. Like them, it is a predatory marine mollusc which grasps its prey in arms arranged round a parrot-like beak, and swims backwards by squirting water from a muscular funnel. But it differs fundamentally from all other living cephalopods. Its large external shell contrasts with their nakedness, or their vestiges of shell buried beneath the skin (cuttle "bone" and the pens of squids). Instead of eight or ten muscular arms fitted with cup-like suckers, it has three dozen slender, contractile tentacles, finely puckered so that they grip. Its blank, button-like eye is a crude pinhole camera, open to the sea-water and without a lens, while other cephalopods have eyes extraordinarily like our own. Correspondingly, its nervous system is simple and diffuse, while theirs are organised into the best brains among the invertebrates. Less obviously, it has four feather-like gills instead of two, an incomplete funnel and no sepia-squirting ink-sac.

In fact, *Nautilus* is a "living fossil", last remnant of primitive cephalopods whose shells appear early in the fossil record and which became a highly successful group in the Mesozoic seas. Even more successful were a late offshoot, the ammonites, which flourished enormously in a bewildering variety of forms before dying out completely. The more advanced naked cephalopods have taken the place of both these shelled groups (though fish have displaced them from their dominant position), of which only *Nautilus* lingers on to give us some idea of the animals within the shells.

Although *Nautilus* has much the largest shell among contemporary molluscs which swim, it floats freely in the water, since all the inner chambers are filled with gas. The soft, compact animal occupies only the last and largest chamber, whose open end it can close by pulling down the hard wedge-shaped hood above its head. It is not directly attached to the shell as a snail is, though it never leaves it, and periodically as it grows it shifts forward into the wider part of the shell. Its rounded hind end then lays down another partition, through which the animal maintains connexion with the inner chambers by a living strand in the siphuncle, which probably keeps them filled with gas from the pale-blue blood.

The name *Ναυτιλοσ*, a sailor, was given by Aristotle primarily to the Paper Nautilus, a surface-swimming octopus found in the Mediterranean which forms a membranous spiral as a shelter for its brood. This is now called *Argonauta*, since Linnaeus used the old name for the Pearly Nautilus. Indeed, it seems that Aristotle must have known something of the remote and extraordinary *Nautilus*, which was afterwards known only as a shell until the 18th century.

CERENKOV RADIATION

J. V. JELLEY, Ph.D., B.Sc.
United Kingdom Atomic Energy Authority

At the International Conference in Geneva last summer on the Peaceful Uses of Atomic Energy, one of the exhibits which attracted most interest was the so-called "swimming-pool" reactor, on show from the United States. When this reactor was working, even at quite low power levels, one could see that the water in which the reactor was immersed was continuously emitting an intense bluish-white light. This light, which is known as Cerenkov radiation, arises through the passage of the fast moving electrons from the core of the reactor (or pile) through a dielectric medium, in this case water. It is perhaps as a result of this exhibit that many people have for the first time met the phenomenon of Cerenkov radiation. All radioactive sources emitting fast electrons or γ-rays produce this radiation in transparent media, though in most cases the light is far too weak to be seen with the unaided eye. However, in the case of a reactor containing water, which itself serves to screen the observer from the dangerous activities of the pile, the level of radiation is so high that the accompanying light is bright enough to see. Although the phenomenon may be new to most readers, it has been known to physicists since the beginning of the century. Its interpretation, however, came not until many years later, in 1937. Let us now trace historically how the effect was first observed and how physicists arrived at a satisfactory explanation of its origin.

Those who have read the life of Madame Curie may remember the great excitement she and her husband experienced when they entered their laboratory in the dark at night, noticing that their bottles of concentrated radium solutions were always aglow with an uncanny pale blue light. Their preoccupation with the much more important discoveries in radioactivity probably prevented their investigating the causes and nature of this luminescence. No doubt many other workers in the field of radioactivity in the early days had also noticed this curious glow of transparent solids and liquids in the proximity of strong radioactive sources. It began to be realised that the phenomenon was of a nature different from that of the true fluorescence, which is known to occur, for example, when certain crystalline materials such as zinc sulphide, calcium tungstate, and various salts of uranium are irradiated by the "rays" emitted from radioactive bodies. A Frenchman by the name of Mallet appears to have been the first to investigate the new phenomenon carefully, concentrating on studies of the spectrum of the radiation. Mallet, whose work was carried out between 1926 and 1929, found that the light emitted from a wide variety of transparent bodies close to a radioactive source always had the same bluish-white quality and that the spectrum was continuous, not possessing the line or band structure characteristic of fluorescence. He used such diverse media as ice, water (both still and flowing), alcohol, carbon disulphide, oils, and albumen, among others. Unfortunately Mallet did not pursue the work, neither did he attempt to offer an explanation for the origin of the light.

CERENKOV'S INVESTIGATIONS

It was five years later, in 1934, that the Russian physicist Cerenkov, at the Physical Institute of the Academy of Sciences in Moscow, started an exhaustive study of the phenomenon. He continued the work for a period of about four years. Cerenkov appears to have been unaware of the earlier work of Mallet, though he too met the problem accidentally, through studies of fluorescence. Cerenkov's experiments covered a wider range than Mallet's; first he measured the relative intensities of the light from different pure liquids, confirming that the spectra had no colour bands. Moreover, he then found that, unlike normal fluorescence, the intensity did not depend on the temperature nor could the light be quenched by adding impurities to the medium. Cerenkov's more significant discoveries, however, were that the light had unique polarisation properties and, most important of all, that its emission was markedly directional. The light travelled out along the surface of a cone, the axis of which coincided with the direction of the radiation, while the angle of the cone appeared to depend on the energy of the exciting particles. Cerenkov offered no explanation of this strange light, a process quite new in the field of optics. Wawilow proposed the theory that perhaps it was a form of radiation associated with the slowing down of the electrons from the radioactive source, akin to the production of the continuous x-ray spectrum when fast electrons impinge on the target of an x-ray tube. There were, however, several objections to this theory, and it was not until 1937 that the Russian theoreticians Frank and Tamm, also at the Institute in Moscow, worked out the correct interpretation of the effect in terms of the classical electromagnetic theory of light.

It is convenient at this stage to state in simple terms precisely what Cerenkov radiation is and when it occurs. In Frank and Tamm's own words, "an electron moving in a medium radiates light if it is moving uniformly, provided that its velocity is greater than the velocity of light in the medium". The effect is then a direct optical analogue of the supersonic bang from an aircraft moving faster than the velocity of sound in air.

HOW THE PHENOMENON ARISES

How does the phenomenon arise? Let us suppose we have an electron moving swiftly through a piece of glass (or any other transparent medium). Fig. 1 shows a highly magnified section of the glass in the vicinity of the track AB of the electron, where the circles represent the individual atoms composing the glass. In general they will be roughly spherical in shape and undistorted. However, in the region close to the passing electron, which at a particular instant in time is for instance at the point P, the electric field of the particle distorts the

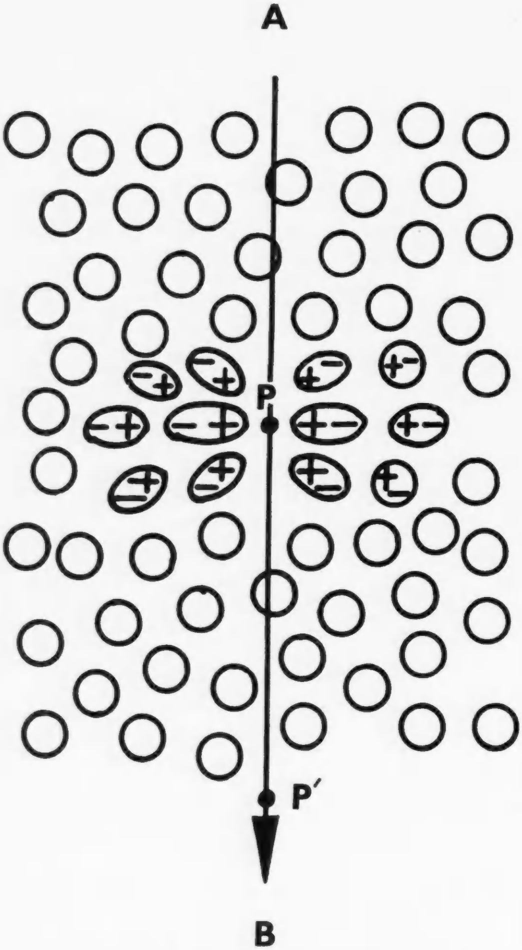


FIG. 1. To illustrate the local polarisation within a piece of glass close to a fast electron; the origin of the Cerenkov effect.

atoms so that the negative charges of their electrons are displaced to one side of the heavier positive charges of the nuclei of these atoms. We say that the medium is polarised, in just the same way as glass is polarised when it is placed between the plates of a condenser charged to a high potential. When now the electron moves on to another point, say P', the strained and elongated atoms around P return immediately to their normal shape. While the atoms are distorted they appear as minute dipoles, with the positive poles near the electron track and the negative poles pointing away from the track. Thus every elemental region of the glass along the track of the electron receives a very brief electrical twitch as the particle goes by, and the tiny dipoles, in their oscillations, will radiate much in the same way as a short-wave transmitting aerial. In this case, however, the frequencies of the oscillations correspond to wavelengths in the optical region of the spectrum.

This is not, however, the complete story, for we have considered only the radiation from a single element of the track. At a point far away compared with the spacing of the atoms, it is the radiation from the *whole* track that has to be considered, since the wavelets from all the separate elements will interfere with each other, depending on their relative phases. In the general case, when the particle is not fast enough, the radiation from each element of track is in fact cancelled by that from some neighbouring element. However, *if* the particle is moving fast enough, the wavelets all add up in phase (called coherence in optics) and the track radiates as a whole, along a wavefront inclined at one particular angle with respect to the track.

The condition for this coherence is quite simply arrived at by reference to Fig. 2(*a*). Suppose an electron traverses a thin slab of glass from A to B at a velocity βc, where c is the velocity of light in free space while β is the ratio of the velocity of the particle to that of light and is always less than unity. It is easily seen that there is only one angle θ at which the light can be emitted, namely that for which the wavelets from individual elements of track, such as P_1 P_2 P_3, are in phase. This will occur when it takes the same time Δt for the particle to go from A to B as it takes the light to go from A to C. For the particle, $\Delta t = \beta c \times AB$, and for the light $\Delta t = (c/n) \times AC$ since the velocity of light is (c/n) in the glass, where n is its refractive index. From these conditions, it is seen that there is a very simple relation between the angle θ, the speed of the particle βc and the refractive index. This relation, known as the "Cerenkov relation", is:

$$\cos\theta = \frac{AC}{AB} = \frac{1}{\beta n}.$$

From this simple equation are derived two special conditions, imposed by the fact that $\cos\theta$ can only lie between the value 0 and 1. There is a *threshold condition* such that when $\theta = 0$, $\beta_{\text{min.}} = 1/n$, so that electrons going more slowly than (c/n) will produce no light. There is also a condition for the *maximum angle* for the light emission, when the speed of the particle is very close to that of light; i.e. when $\beta \to 1$, then $\beta_{\text{max}} \to \cos^{-1}(1/n)$.

Fig. 2(*a*) was only drawn in one plane. In practice the light is emitted on the surface of a cone as shown in Fig. 2(*b*), the angle θ now being the semi-apex angle of the cone. The light is polarised in such a way that the electric vector E is everywhere perpendicular to the surface of the cone and the magnetic vector H tangential to the surface. The light, which has a spectral distribution inversely proportional to the cube of the wavelength, is thus much more intense in the blue, short wavelengths, than in the red, long wavelengths. The intensity of the radiation is extremely weak, amounting to only about 4×10^{-10} erg for an ultra-fast electron plunging through a depth of 1 centimetre of water; this figure for the light intensity is based on a spectral region

Cerenkov Radiation as seen in the U.S. Swimming-pool reactor. The radiation shows as a ghostly blue light, and does not resemble fluorescence. (*Reproduced by kind permission of the U.S.A.E.C.*)

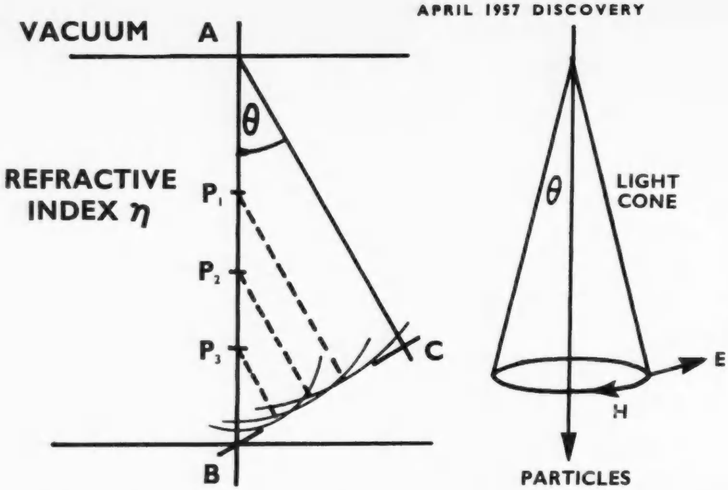


FIG. 2. (*a*) The formation of the coherent wavefront in Cerenkov radiation.
(*b*) To illustrate the formation of the cone of light, and the disposition of the vectors of the electromagnetic field.

from violet to orange, that is, from 4000 to 6000 Ångstroms wavelength. For those familiar with the concept of quanta it amounts to about 100 photons/cm. of track. In water, for example, for which the refractive index is 1·33, the threshold energy for electrons is 260 keV. If the electrons have an energy of 500 keV, the light is emitted at an angle of $\theta = 31^\circ$ and the radiation output is about $3{\cdot}8 \times 10^{-10}$ ergs (or 95 photons) per cm. path. At very much higher energies, for which we get 4×10^{-10} ergs/cm., the cone angle increases to its maximum value of $\theta_{max.} = 41^\circ$.

It should be emphasised that in terms of energy loss, the amount going into the form of Cerenkov light is only a very small fraction of the energy lost by ionisation, in fact about 0·5%. It is also important to realise that the distortion of the atoms is really very small, quite inadequate to excite or ionise them: the light, therefore, is not to be confused with that which may also be associated with the ionisation itself. In most pure solids and liquids, however, the light associated with ionisation is quite negligible compared with the Cerenkov radiation, as it also is in the case of air at atmospheric pressure. The light of the Aurora is, however, an example of light produced by ionisation. The Aurora is excited by slow protons from the sun. Their low velocity, combined with the extremely small refractive index of air at great altitudes, precludes Cerenkov radiation from taking place; the low air pressure at these altitudes is, at the same time, favourable for the generation of light by ionisation.

APPLICATIONS OF THE RADIATION

Having discussed at some length the underlying principles of Cerenkov radiation we will now turn to some of its diverse and very useful applications, particularly in the fields of nuclear physics and cosmic-rays. Cerenkov radiation has been used as the basis for new types of detectors and counters for fast particles, and it is these applications that have brought its study to the fore in the last few years. Radiation detectors based on the Cerenkov effect usually employ photomultipliers to detect the very weak pulses of light, though occasionally, when used with sufficiently intense beams of particles, photographic recording of the light is possible. It was the rapid development of the photomultiplier just after the war that gave such an impetus to work on Cerenkov radiation, as indeed it also gave to the development of the Scintillation counter. The photomultiplier is by far the most sensitive light detector known and can detect single photons with an efficiency approaching 20% for some tubes. In order to appreciate the range of its applications, let us see what properties Cerenkov detectors will possess, from the simple description of the process outlined above.

Cerenkov counters can be used as threshold detectors, that is, detectors which will record only those particles passing through them for which the velocity, and therefore energy, exceed a certain critical value, as already mentioned. Thus it is possible to count single fast particles against a very intense background of much slower particles. A corollary to this property is the ability to select particles of a given mass, provided their energy is known, since the latter is given by $\frac{1}{2}mv^2$ where m and v are the mass and velocity of the particles. An example of the use of such a detector as a threshold counter is that selecting the few cosmic-ray protons at sea-level against the high background of mesons and electrons, the protons moving too slowly to produce Cerenkov light. Dr Duerden and Dr Hyams at Manchester University first carried out such experiments with a simple water detector, selecting those particles known to have passed through the detector but which did not give a pulse from it. Cerenkov detectors of special design played an important rôle in the recent exciting discovery of the negative proton at Berkeley in California, the threshold feature of the instruments serving to select particles of the right mass since their velocity was measured by other means. The essential features of this great discovery have already been discussed in an article in these pages by Prof. O. R. Frisch of the Cavendish Laboratory, Cambridge (DISCOVERY, December 1955, p. 498).

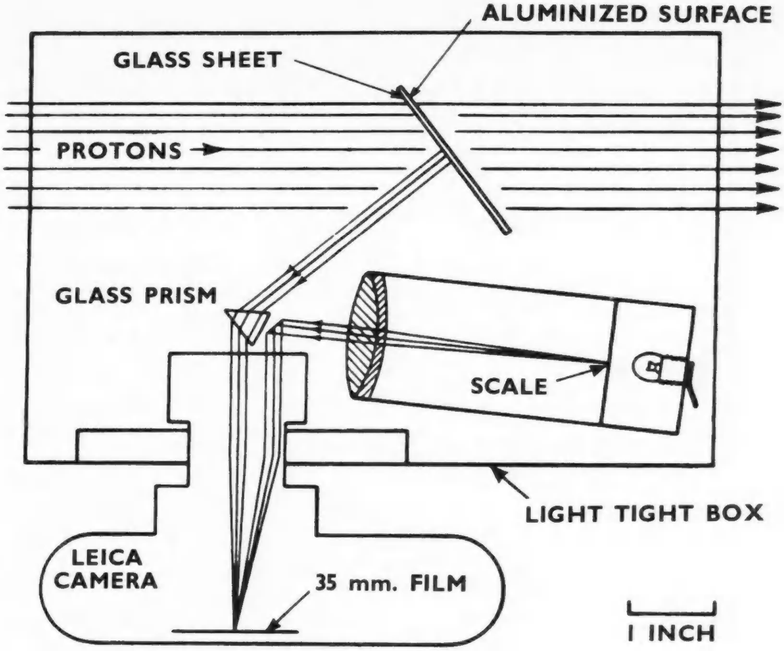


FIG. 3. The photographic Cerenkov detector of Mather's, used to measure the energies of protons from a large synchrocyclotron in California.

We have so far only mentioned applications for which it is required to know that the velocity of the particle is above or below the threshold value; however, it is possible to measure accurately the velocity of the particles in certain cases, in an energy region in which θ is varying rapidly with β. Dr Mather, at the University of California Radiation Laboratory, used a very simple but elegant photographic instrument to measure the energy of the external beam of protons from the synchrocyclotron there. The essential features of this instrument are shown in Fig. 3. The Cerenkov radiation is produced in a thin sheet of glass, 0·67 millimetre thick, tilted at such an angle that a very small portion of the cone of light strikes the back of the glass at normal incidence; this light is then reflected back through the glass, since its rear surface is aluminised, and enters a Leica camera via a small prism. After fairly long exposures, of the order of minutes, a small arc-shaped image appears on the recording film. The purpose of the prism is to cancel dispersion inherent in Cerenkov radiation. Proton energies coula be measured to an accuracy of about $\pm 1\%$ with this instrument.

Many versions of Cerenkov counter have been made for measuring the velocities of protons and π-mesons produced by the large nuclear physics machines; most of these use photomultipliers rather than photographic recording. Dr J. Marshall of the University of Chicago was one of the first to develop suitable forms of counter for this purpose.

Another use of Cerenkov counters depends on the directional property of the light. It was through this that the author first detected in 1951 single cosmic-ray particles by the Cerenkov effect. He used a detector of the simplest type, consisting of a cylindrical container 20 centimetres long, filled with distilled water, mounted above a photomultiplier. It worked on cosmic-ray μ-mesons which come downwards from the atmosphere and produce a few counts per minute. When the whole apparatus was turned upside down the counts almost disappeared, since the light cone could no longer reach the photomultiplier. Counters of this type have been flown with balloons by Winckler in America to heights of over 100,000 feet, to measure the cosmic-ray "albedo", that is, the proportion of fast particles at high altitudes travelling upwards to those travelling downwards.

Recently some experiments of quite a different nature have been carried out by Dr Galbraith and the writer at the Atomic Energy Research Establishment at Harwell, in which they have studied light flashes from the night-sky associated with showers of high-energy cosmic-ray electrons in the atmosphere. In this application of Cerenkov radiation, no special counters are used since the atmosphere is itself the light producing medium. That faint light should be produced at night in this way was predicted by Prof. Blackett in 1948, but it was not until 1952 that these light flashes were first discovered by us. For this work which can only be carried out on clear, moonless nights, we used a simple reflecting telescope consisting of a parabolic mirror 10 inches in diameter at the focus of which was placed the photosensitive surface of a photomultiplier, see Fig. 4. The first apparatus was mounted in a domestic dustbin which

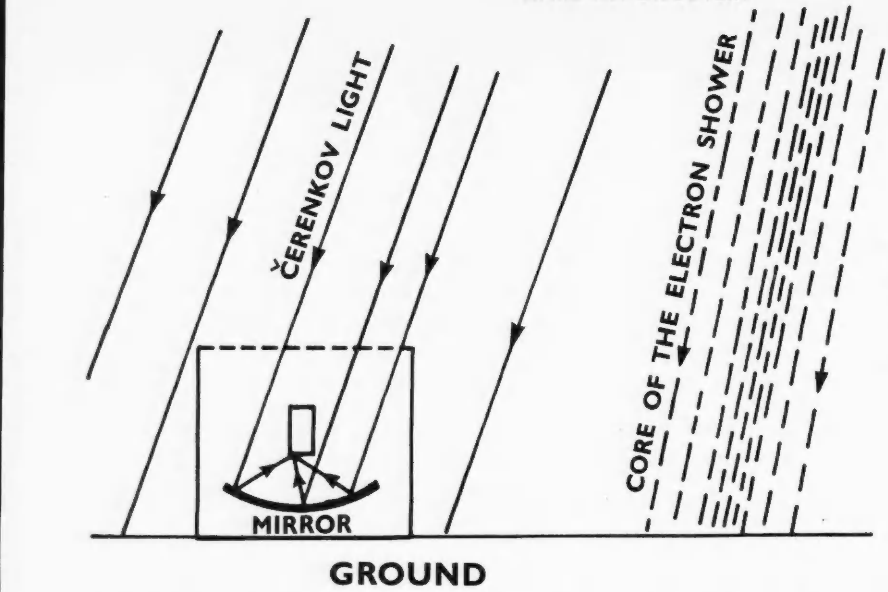


FIG. 4. The simple light receiver used by Galbraith and the writer, to pick up light pulses from the night sky associated with showers of cosmic-ray electrons in the atmosphere.

acted as a light screen. The light pulses are extremely short, of duration probably of the order of 10^{-8} seconds, and arrive at a rate of few per minute. The electron showers with which the light is associated, are detected by Geiger counters placed on the ground around the light receiver. We continued this work at the Pic du Midi Observatory in France in 1953, where we were aided by the much greater clarity of the atmosphere.

To summarise, we have seen that Cerenkov radiation, though a small aspect of physics, has unique features whereby it has become a powerful tool of the nuclear and cosmic-ray physicists.

READING LIST

For further general reading see, for example, the review article by the writer, in "Progress in Nuclear Physics", 1953, vol. 3, p. 84, edited by Prof. O. R. Frisch, and published by Pergamon Press, London. Also:

Blackett, P. M. S., *Gassiot. Comm. Phys. Soc.*, 1948, p. 34.

Cerenkov, P. A., *C.R. Acad. Sci.* (U.S.S.R), 1934, vol. 2, p. 451, and *Phys. Rev.*, 1937, vol. 52, p. 378.

Curie, Eve, "Madame Curie".

Duerden, T., and Hyams, B. D., *Phil. Mag.*, 1952, vol. 43, p. 717.

Frank, I., and Tamm, Ig., *C.R. Acad. Sci.* (U.S.S.R.), 1937, vol. 14, p. 109.

Galbraith, W., and Jelley, J. V., *J. Atmospheric and Terrestrial Physics*, 1955, vol. 6, p. 250, and 1955, vol. 6, p. 304.

Jelley, J. V., *Proc. Phys. Soc.* (London), 1951, vol. A64, p. 82.

Mallet, L., *C.R. Acad. Sci.* (Paris), 1926, vol. 183, p. 274, and 1929, vol. 188, p. 445.

Marshall, J., *Phys. Rev.* 1952, vol. 86, p. 685.

Mather, R. L., *Phys. Rev.*, 1951, vol. 84, p. 181.

Winckler, J. R., and Anderson, K., *Phys. Rev.*, 1954, vol. 93, p. 596.

UNIVERSITY COURSE ON SPACE TRAVEL

The Extra-Mural Department of Manchester University has been enterprising enough to organise what is probably the first University Course on Space Travel. This University Extension Course of seven lectures took place from January 16 to February 27. J. Ring, Lecturer in Physics, spoke on "Space Travel in Fact and Fiction", and F. D. Kahn, Lecturer in Astronomy, followed with a lecture entitled "Beyond the Earth's Atmosphere", designed to give a picture of the Universe, the extent of space, the nearest bodies in our own galaxy, and the possible objectives of space travel from the Earth. The third lecture was by J. H. Gerard, Lecturer in Mechanics of Fluids, on "Aerodynamics and the Possibilities of Flights through Outer Space"; and the fourth, again by J. Ring, was on the "Necessity for Artificial Satellites and the Problem of Interstellar Navigation", including a discussion of fuel, food, water, and other needs. Lecture 5, by Z. Kopal, Professor of Astronomy, and lecture 6, by J. G. Blower, Lecturer in Zoology, were on "Physical Considerations of Space Travel", and described the conditions which might be expected on our neighbouring planets, our ability to exist there, the effect of radiation on cells, and the effect of cosmic radiation as known on the Earth's surface, together with a discussion on what might be the effect on the human body when travelling in outer space without the protection of the atmosphere. J. Ring concluded the series with a general discussion of the objects and purposes of space travel and its possible benefits to the human race, under the general heading, "What do we do when we get there?"

The following books were recommended for the course: Burgess, "Rockets and Space Flight", and "Frontier to Space"; Boyd and Seaton, "Rocket Exploration of the Upper Atmosphere"; Newell, "High Altitude Rocket Research"; G. Fletcher Watson, "Between the Planets"; Eddington, "The Expanding Universe"; Ower and Nayler, "High-Speed Flight"; Whipple, "The Earth, Moon, and Planets"; Russell, "The Solar System and its Origin"; Jones, "Life on other Worlds"; Kalmus, "Genetics" (Pelican) and *Science News No. 2* (Pelican).

There was a good attendance at the course, and the enthusiasm was such that questions continued well after the time scheduled for the end of the lecture.

SUBJECTIVE TIME

JOHN COHEN, M.A., Ph.D.

Professor of Psychology, The University of Manchester

The recent correspondence on space travel and ageing in *Nature** and DISCOVERY† was prompted by the idea that when travelling at velocities close to the speed of light the hypothetical traveller's metabolism would be slowed down in a way similar to that produced by lowering his temperature. If so, he would age more slowly than his terrestrial friends that he left behind. A further implication is that the duration of his journey, as compared with what clocks on Earth have measured, would seem to him longer than it would to his friends on Earth. The correspondents did not refer to other aspects of the subjective time of the traveller or the terrestrial observer, no doubt because, strictly speaking, they are not germane to the issue. Nevertheless, the impression may follow that variations in estimates of clock time due to metabolic changes are the only distinctive features of psychological as compared with physical time. This is not, however, the case.

The dependence of judgements of apparent duration upon temperature was first demonstrated by Prof. Henri Piéron, who extended to temporal phenomena the idea underlying the equation of Arrhenius, which relates chemical velocity to temperature. If our temperature is raised, we think clock time is passing slowly; if it is lowered, we think it is it passing quickly. The behaviour of animals is similarly affected by an increase in temperature; the hearts of cockroaches beat more rapidly and crickets chirp more frequently. But this functional dependence of apparent duration on the velocity of organic process, important though it is, is merely one comparatively simple aspect of subjective time. It does not account for the many sources of variation in subjective time which have nothing to do with temperature.

Subjective time includes our *experience* of all the temporal aspects of events in our lives in contrast to a physical record of them, where that is possible, independently of experience. This experience is subject to variations due to such things, for example, as nostalgia, pain, joy, hope, and the workings of memory, which cannot occur in physical time. Certain discrepancies between subjective and physical time are therefore bound to arise. All the same, there is a fundamental concordance between them, and, indeed, this must be implied in the very idea of human evolution.

Among the many forms of subjective time which we can identify are (*i*) apparent duration, that is, how long an event or interval *seems* to last; (*ii*) experience of the sequence and "pastness" of events; (*iii*) temporal localisation; (*iv*) "sinceness"; and (*v*) "futureness". Something must now be said about each of these forms of temporal experience. They have been selected because they are in a way "measurable", but I do not wish to deny psychological reality to non-measurable aspects of time, such as, for example, Bergsonian duration, in the sense of the experience of a continuous and uninterrupted flow which underlies all succession and change.

* *Nature*, 1956, vol. 177, p. 782, and vol. 178, p. 680.
† DISCOVERY, 1957, vol. 18, p. 56, and this issue, p. 174.

An ancient symbol of Time: the Mithraic god Aion (also called Chronos or Deus leontocephalus) with signs of the Zodiac and other features signifying aspects of time. Rome, second–third century. From C. G. Jung's "Symbols of Transformation", London: Routledge and Kegan Paul, 1956, Plate XLIV. (*With acknowledgements to the publishers.*)

(*I*) SUBJECTIVE DURATION OF TIME

Everyone knows that the hands of the dentist's clock crawl and that the days fly when we are on holiday. We over-estimate the physical interval in the first case, under-estimate it in the second. Under the influence of such drugs as opium and mescalin, in psychosis and in certain physical diseases, these subjective distortions may be enormously magnified. They are only "distortions", of course, from the physicist's point of view. Psychologically they are natural phenomena; they are as real as the desk in front of me and have as much claim to the respectable status of a fact as any other fact in nature.

We must, however, distinguish what normally happens in the hurly-burly of everyday life from our *capacity* to make accurate judgments of duration. When we are relatively free from the influence of strong emotion, the deviation of our subjective estimates from the objective record, though systematic, is not necessarily large. We are more accurate in judging short intervals up to about 5 or 6 seconds than in judging longer intervals. In judging short periods we are able to concentrate on the

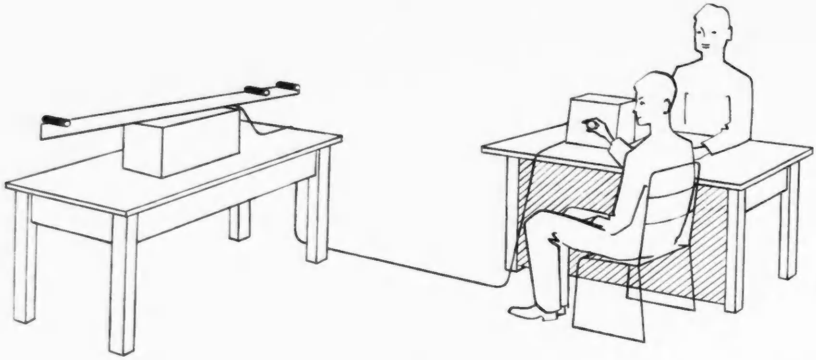


FIG. 1. Subject adjusting the time intervals between the flashes (experiment on *kappa*-effect).

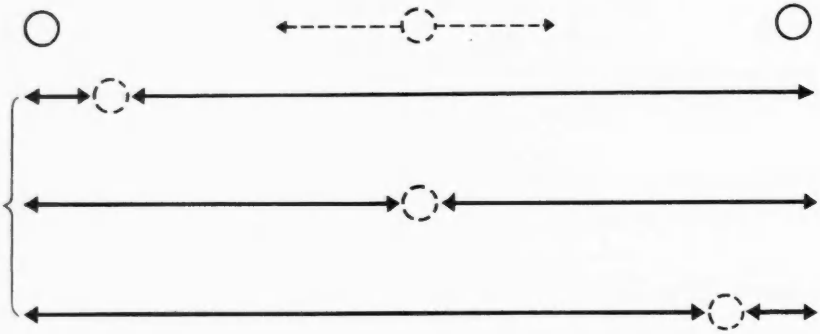


FIG. 2. Time intervals judged equal by subject when the centre light is at three different positions.

interval itself directly, but when we estimate minutes or hours we find that the mind wanders, so our judgments become indirect and based on such cues as the number or kind of activities or events that have filled the time.

In judging short intervals there is a systematic tendency to over-estimate. We tend to think a second is shorter than it is by clock time. On the average, 1 second is called 1·5 seconds and 4 seconds is called about 6 seconds. Attempts to construct a scale of subjective duration, as Prof. Stevens of Harvard has observed, show that the subject's ability to distinguish one duration from another varies in different parts of the scale and consequently affects the width of the categories into which he places them. He can easily discriminate 0·5 from 1·0 second, so he puts them in different categories, whereas he tends to put 3·5 seconds and 4·0 seconds in the same category because of his difficulty in distinguishing them.

Judgments of duration affect and are affected by other simultaneous experiences. In this respect they resemble well-attested inter-sensory phenomena which reveal the integration and unity of the senses. Thus the *tau*-effect* shows that judgments of spatial distances depend on the temporal interval taken to traverse them. If three points (p_1, p_2, p_3) are marked on the subject's skin and the interval of time between stimulating p_2 and p_3 is greater than that between p_1 and p_2, the subject judges the distance between p_2 and p_3 as greater than that between p_1 and p_2, though physically it may be equal or less. Similar results are obtained if visual stimuli are substituted for tactile ones. We have recently demonstrated at Manchester the reverse phenomenon, namely, that temporal judgments of the duration of space-time events are systematically affected by the spatial component.* This is now known as the *kappa*-effect. It may be exemplified as follows: the subject faces a continuous cycle of three separate flashes of light. He can control the

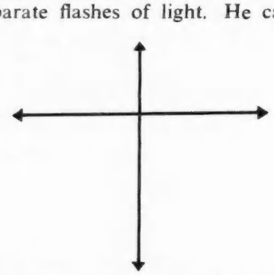


FIG. 3. Diagram representing the relative magnitude of the *kappa*-effect with variation in the direction of the flashes relative to the ground.

* Helson, H., and King, S. M., "An Example of Psychological Relativity", *J. exp. Psychol.*, 1931, vol. 14, p. 202.

* Cohen, J., Hansel, C. E. M., and Sylvester, J. D., "A New Phenomenon in Time Judgment", *Nature*, 1953, vol. 172, p. 901; "Interdependence of Temporal and Auditory Judgments", *Nature*, 1954, vol. 174, p. 642; and "Interdependence in Judgments of Space, Time and Movement", *Acta Psychol.*, 1955, vol. 11, pp. 360–72.

timing of the middle flash and has to make the interval of time between the first and second flash equal to that between the second and third (see Fig. 1). Under these conditions he allots a shorter time to the larger of the two distances, and the bigger the ratio of the two distances, the shorter, relatively, is the time he allots to the flashes spaced farther apart. If we call the distance between the first and second flashes d_1, between the second and third flashes d_2, and the corresponding intervals of time t_1 and t_2, then $\frac{t_2}{t_1}$ decreases as $\frac{d_2}{d_1}$ increases (see Fig. 2). The magnitude of the effect is indicated by the fact that when $\frac{d_2}{d_1}$ is $\frac{1}{10}$ the subject under-estimates by 12% and when $\frac{d_2}{d_1}$ is $\frac{10}{1}$ he over-estimates by 13%; and it appears to be influenced by the direction of the flashes of light relative to the ground, for it is smallest when the lights flash in the upward, greatest in the downward, and intermediate in the horizontal direction (see Fig. 3). From the *tau*- and *kappa*-effects we may conclude that the spatial and temporal components of space-time events are experienced as interdependent. There is, therefore, a mutual relativity in subjective space-time.

An auditory *kappa* may be produced if the intervals are delimited by auditory pitch instead of by flashes of light. If the subject listens to two different continuous tones and tries to assign an equal duration to each one, he tends to allot a shorter duration to the higher tone, an effect which becomes more marked as the difference between the two tones increases.

This interdependence in spatio-temporal experience is analogous to the subjective interdependence of auditory pitch and loudness in contrast to the mutual independence of the frequency and intensity of sound-waves. Phenomena such as these conflict with the assumption that experience is composed of separate elements which correspond to autonomous physical dimensions of stimuli, the so-called "mind" being merely a replica of what is physically presented to the brain. On the contrary, it seems that the qualities of experience have their own intrinsic structure and interrelationships.

Let us indulge in a momentary play of fancy at this point. Imagine that something like the *kappa*-effect holds for the experience of movement in inter-planetary voyages. Our traveller must be subjected to acceleration when he embarks and when he turns round and to deceleration when he lands. His judgment of the duration of the parts of his journey which vary in velocity would then be influenced by the corresponding distances through which he has travelled during the respective intervals. The time spent over the longer distance would seem disproportionately long and the time over the shorter distance disproportionately short, as compared with clocks on the space-ship. This might hold true on a smaller scale for a man who flies blindfolded from London to Paris in an hour and continues the journey to Cairo in another hour. The second lap of his journey might seem to him much longer than the first.

(*II*) SEQUENCE AND "PASTNESS"

The fact that the sequence of two events may be experienced in the reverse order of their physical occurrence was noticed by Ernst Mach,* who may be said to have initiated the experimental study of subjective time in his researches into the auditory time sense in 1865. In his study† of the sensations twenty years later he declared that "the time of the physicist does not coincide with the system of time sensations", and he attributed our sense of time to the effort of attention. If, for example, a doctor directs his attention to the patient's blood, he may see it flow before the lancet penetrates the skin. For similar reasons, the weaker of two stimuli presented simultaneously usually seems the later of the two.

Normally we are able to recall past experiences or events in a sequence which corresponds, roughly, at any rate, to the serial order in which they occurred, each experience having a certain quality of "pastness" associated with it. As Sir Russell Brain‡ has remarked, this orderly recall is an essential element in the sense of personal identity. It is disrupted in early senile dementia and in certain states of insanity.

(*III*) TEMPORAL LOCALISATION

This means the ability to locate our earlier experiences in our personal life histories, placing them in the mental maps of the past. In this respect subjective time resembles touch, whereas in another respect it resembles pain. The likeness to touch lies in the fact that the temporal localisation of an experience is separate and distinct from the mere recollection of it. We can know that something has happened without being able to say *when*, just as we can know *that* we have been touched without knowing *where*. Subjective time resembles pain in that attention is essential in both types of experience.

(*IV*) "SINCENESS"

By "sinceness" I mean the feeling of how long it seems since a given event. Estimates of elapsed time based on such feelings may show surprisingly little error even after a period of three days and nights without cues to clock time. An experiment carried out some years ago, in which two persons were placed for 48 and 86 hours respectively in a sound-proof room without cues for time, showed that the error at the end of the period was only 26 minutes in the case of the first subject, and 40 minutes in the case of the second.§

The experience of "sinceness" may be spatially represented by asking the subject to mark off, on a given line, a length corresponding to the lapse of time since a certain experience: how long it seems since yesterday's lunch, since Christmas, since he left school, and so forth. Such spatial representation shows a certain pattern. If

* Mach, E., "Untersuchungen über den Zeitsinn des Ohres", *S. B. Akad. Wiss. Wien*, 1861, vol. 51.

† Mach, E., "Contributions to the Analysis of Sensations", Chicago, 1897 (first German edition, 1886).

‡ Brain, W. R., "Diseases of the Nervous System", London, Oxford University Press, 1951, 4th edition.

§ MacLeod, R. B., and Roff, M. F., "An Experiment in Temporal Disorientation", *Acta Psychol.*, 1936, vol. 1, pp. 381–423.

the lengths of line marked off for the various periods of elapsed time are plotted against the logarithms of the corresponding chronological intervals, we obtain a straight line. This holds for intervals up to about six months from "now", and conforms with what one would expect on the basis of Weber's law, that is, that the just noticeable difference in perception occurs when the stimulus is changed by a more or less constant proportion of itself. In the form given to it by Fechner, this law may be roughly stated as: perception is proportional to the logarithm of the stimulus. Thus as the actual intervals of time increase logarithmically, the estimates increase in approximately linear fashion. Estimates of intervals up to about six months from "now" show a relative contraction as they become more and more remote from the present. Estimates of intervals greater than a year from "now", however, do not show this contraction. They are more or less linear. Intervals between six months and one year may be estimated by either of the two methods. Something that happened an hour or a day ago seems disproportionately remote as compared with a week or month ago, but there is no disproportion when, for example, two years ago are compared with ten years ago.*

An analagous phenomenon of the relative contraction of time is experienced as we get older, the calendar years seeming progressively to shrink. This phenomenon has been linked with biological time, which Lecomte du Nouy has studied in relation to the rate of healing of wounds at different ages.

(V) "FUTURENESS"

Subjectively a future is presupposed in all our activities. Without a tacit belief in a tomorrow, our lives would be meaningless. We expect, intend, anticipate. We have premonitions and presentiments. Our hopes for the future are the counterpart of our nostalgia for the past. Implicit in all that we do today are plans for tomorrow, for next week, possibly for years ahead. Often this is deliberate, as in saving and investing money. Even in the simplest creature there is what Sherrington† described as a "germ of futurity" and it is surrounded by "a shell of its immediate future". As we move up the phyletic scale this temporal horizon extends further and further ahead. In man, increasing age from infancy onwards also brings a larger temporal horizon or perspective, a capacity which seems to be served by the pre-frontal lobes of the brain, for it seems reduced after leucotomy or lobectomy. Human language may have originated probably in the Upper Palaeolithic period when our ancestors were capable of making a forward as well as a backward reference in time, leading to the separation of the intelligible from the emotive aspects of speech.‡

Our orientation to the future may show a gradient of tension. We are apt to become increasingly alert as an expected event approaches. The sleeper becomes more and more restless as the pre-appointed moment of waking draws near. An examinee experiences mounting tension as he awaits his results. A pregnant woman awaiting the birth of her child, a bridegroom the marriage ceremony, and a prisoner his execution, all probably undergo a similar increase of tension. Such temporal gradients can sometimes be studied experimentally. Pavlov's dog, trained to receive meat every 30 minutes, showed by changes in breathing and salivation that he "knew" when the time for the next feeding was due. It can be shown, for example, that a person's ability to recall or recognise a task which he has begun and left unfinished depends not so much on the amount he has done as on what remains to be done; the less time needed to complete the task, the more likely he is to be able to recall it regardless of how much time, within limits, he has spent on it.*

OTHER VARIATIONS IN TIME SENSE

In this article I have limited myself to certain aspects of "measurable" personal time, to what might be called the phenomenology of temporal experience. I have not discussed variations in the conception and quality of time from culture to culture, from age to age, from savage to civilised society or from one occupational group to another within any community. I have not dealt either with the reciprocal interplay between present and past experience which is one of the aspects of memory, nor with the psychopathology of time, the transformations of temporal experience that occur in insanity and under the influence of drugs.† The nature of subjective time in myths (see photograph, p. 151), dreams, and repressed memories, and, in particular, its relation to the sense of personal identity also deserve separate consideration. I close with a reference to symbolic time, which some readers may recognise from their own experience. The fact that subjective duration seems to have a flowing quality may endow it symbolically with a sexual significance. There are people who hoard their precious time just as there are others who delight in wasting it. Some persons may acknowledge that their joy in dissipating their time has a sexual flavour and they may appreciate the symbolic significance of their valuation of time when their attention is drawn to it. Such joy may extend to dissipating someone else's time. I knew someone who boasted that his greatest delight was to interrupt his fellow-workers in their activities and dissipate their time. He was quick to see, however, that the gratification he drew from these intrusions was not unmixed with autoerotic and other "forbidden" sexual satisfactions he gained elsewhere.

I would like to express my thanks to my colleague, Leon Rosenfeld, Professor of Theoretical Physics, for kindly reading and commenting on a draft of this article.

* Cohen, J., Hansel, C. E. M., and Sylvester, J. D., "An Experimental Study of Comparative Judgments of Time", *Brit. J. Psychol.*, 1954, vol. 55, pp. 108–14.

† Sherrington, Sir C., "The Brain and its Mechanism", London, Cambridge University Press, 1933.

‡ Pumphrey, R. J., "The Origin of Language", Liverpool, The University Press, 1951.

* Cohen, J., "The Concept of Goal Gradient", *J. gen. Psychol.*, 1953, vol. 49, pp. 303–8.

† For a discussion of these aspects of time, see my article, "The Experience of Time", *Acta Psychol.*, 1954, vol. 10, pp. 207–19.

Cossor Kits

In laying down their programme for the design and production of a range of apparatus in Kit Form, Cossor Instruments Limited have chosen as their "opening pair" two most valuable items of test gear; a VALVE VOLTMETER and a single-beam cathode-ray OSCILLOSCOPE.

PRINTED CIRCUITS are utilised for built-in stability and reliability for both of these instruments. Bearing in mind the highly satisfactory specification/cost ratio of these instruments and being aware of the instructional value in building them, the Laboratory or Service Department Engineer will certainly place them high on his list of essential purchases.

Model 1044K Valve Voltmeter Kit

Brief Specification

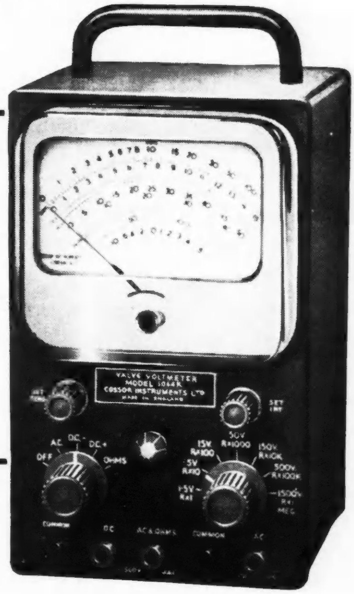
D.C. Voltmeter 7 ranges: 1.5V — 1,500V Full Scale.

A.C. Voltmeter 7 r.m.s. ranges: 1.5V — 1,500 Full Scale.
7 peak-to-peak ranges: 4V—4000V Full Scale.

Ohmmeter 7 ranges: Allowing resistance measurement from 0.1 ohm — 1,000 megohms.

Dimensions

Height: 9½ in. (24 cm.)	Width: 5 in. (12.7 cm.)
Depth: 4¾ in. (12 cm.)	Weight: 4½ lb. (2 kg.)



LIST PRICE £20

HIRE PURCHASE TERMS AVAILABLE

Please write for fully descriptive leaflets

COSSOR INSTRUMENTS LIMITED

The Instrument Company of the Cossor Group

COSSOR HOUSE · HIGHBURY GROVE · LONDON, N.5

Telephone: CANonbury 1234 (33 lines) Telegrams: Cossor, Norphone, London Cables: Cossor, London

SOUNDING THE UPPER ATMOSPHERE

A. L. MAIDENS, B.Sc., F.R.Met.Soc.

Meteorological Office, Air Ministry, Dunstable, England

There is need today for regular and accurate information about meteorological conditions up to the greatest possible height of the atmosphere, and upper-air observations will receive special attention throughout the world during the forthcoming International Geophysical Year. The recent international radio-sonde trials, held in 1956 in Switzerland and attended by thirteen countries, also drew attention to the need for a high and uniform standard of accuracy in upper-air information throughout the world.

Scientific measurements of meteorological conditions became possible with the invention of the barometer and the thermometer in the early 17th century, but for another hundred years the observations obtained by these means remained confined to the surface. When means of raising such instruments above ground level became available, the opportunity was rapidly exploited. As early as 1749 Dr Alexander Wilson of Glasgow made measurements in the free air by thermometers raised by a kite. In 1752 similar experiments were conducted by Franklin, and in 1784 a manned balloon was employed for the first time specifically for upper-air observations.

The relationship between changes of pressure and height, and the effect of air temperature, was first stated by Laplace, and systematic study of these variables followed. A number of manned balloon ascents were made during the earlier part of the 19th century, but such a method was too costly, and too dependent upon weather conditions, to provide frequent and regular observations.

In the second half of the century kites and manned balloons were mostly replaced by small hydrogen-filled balloons which carried the simple measuring and recording apparatus known as the "meteorograph". At a given height the balloon would burst and the apparatus fell to the ground, protected as far as possible from damage by a resilient cane framework, a parachute, or some similar device. Ascents of this type, intended primarily to gain general scientific information about the pressure, the temperature and, later, the humidity of the upper air, were made in large numbers; they continued in Britain until the outbreak of war in 1939. This kind of apparatus reached heights of the order of 60,000 feet.

Obviously such records are valueless unless the meteorograph is recovered and returned to the Meteorological Service; in Britain the selection of a suitable release point, and the promise of a small reward to any member of the public finding the apparatus, has ensured the return of enough records to enable considerable knowledge to be gained about the general structure of the upper atmosphere.

Upper-air observations have been undertaken by all important countries working in close unison. As early as 1896 it was internationally agreed to nominate a particular day on which simultaneous observations would be made over a wide area to provide as complete a picture of upper-air conditions at a given time as possible. Unfortunately countries less populated than Britain had great difficulty in obtaining the return of a sufficient number of records. The use of radio later made automatic transmission of the observations possible as the ascent was in progress. By 1939 most important countries had both radio-sonde and radio wind-direction-finding apparatus; in some countries the equipment was already in use, in others it was merely being developed. The requirements of the war greatly stimulated the installation of suitable networks of observing stations.

Today, under the rules devised by the International Meteorological Organisation, a specialist agency of the United Nations, upper-air ascents are co-ordinated throughout the world. Forecasters of all meteorological services can now rely upon a network of upper-air sounding made simultaneously in all countries at least twice a day. By analogy with maritime procedures, the term "sounding" had come into use in upper-air observations, and so the term "radio-sonde" was used for the first sounding apparatus involving radio transmission.*

RADIO-SONDE AND THE PILOT BALLOON

The first radio-sonde to be flown was a French model devised in 1927 by Idrac and Bureau. It was, however, not until 1930 that a really successful upper-air ascent by radio-sonde apparatus was made, with apparatus designed in the U.S.S.R. by Moltchanoff.

A rough determination of the wind flow above ground level had been made as early as 1809 by Thomas Forster, who observed the drift of small free balloons filled with coal gas. In still air these would rise vertically; their sideway drift was an indication of the wind movement. Much useful information about the general relationship of the surface wind to that of the atmospheric layers above it had been acquired from the many manned balloon flights made during the last

* A few words are needed to explain how the term "sounding" has acquired a new meaning in this context. In marine language the term "sounding", originally limited to the determination of the depth of water, had been extended to include any exploration of the nature of the sea bed or of the ocean itself below the surface. In this case measuring apparatus was lowered through the levels at which observations were required. By analogy, the ascent of measuring apparatus through the atmosphere was similarly described as a "sounding". This term covered any observation which could be made at successive levels of the atmosphere by instruments conveniently carried by a balloon; hence it has come about that one can talk about "soundings" of the distribution of atmospheric electricity, the chemical content of the air at different heights, and other properties of the atmosphere which have been made. For normal routine meteorological purposes, upper air soundings were limited to observations of the atmospheric pressure, temperature, and humidity of the various layers of the atmosphere. Radio sounding was a suitable term to describe transmission of the observations to the ground so the French term *radio-sonde* has been internationally adopted.

century, but the necessity for daily, accurate, and up-to-date information at stated heights was a new thing.

This demand on the meteorologist was met at an early stage in aviation history by the use of the small, free balloon called the "pilot balloon", the movement of which was carefully observed by a specially designed optical theodolite. This method was first tried out in 1909 at Blue Hill in the United States. As in the case of Forster's balloons, the horizontal drift depends only on the wind prevailing at the height reached by the balloon at any moment, and it is possible by measuring this drift to compute the wind in the successive layers of the atmosphere through which the balloon passes. This method, however, depends entirely on the balloon remaining within visual range, and it breaks down if cloud comes between the balloon and the theodolite. The meteorologist turned to radio as a means of overcoming this problem, but nevertheless "pilot balloon" ascents, coupled with optical methods of observation, continue to be used in meteorology.

In this country the first type of radio-sonde employed was known as the "Kew" model, as it originated at the meteorological observatory at Kew. A three-station radio direction-finding system was used to locate the position of the balloon in space. The direction-finding equipment, which followed a signal emitted by a simple transmitter attached to the balloon, determined the bearings of the balloon relative to each of the observing stations, and the position of the balloons above the earth's surface was obtained by the intersection of these three bearings. To assign each wind to its appropriate level in the atmosphere it was necessary also to know the height of the balloon when each measurement was made. This could be done by replacing the simple transmitter by a radio-sonde. The radio-sonde gave data from which height could be calculated and also provided the radio signal necessary for direction-finding. The alternative was to estimate the height of the balloon from its presumed rate of ascent, an unsatisfactory method liable to wide error.

RADAR

In many other countries the radio direction-finding system has continued in use until the present time, but the employment of higher radio frequencies has allowed the multiple station method to be replaced by measurements made from a single station of both the angle of elevation of the balloon above the horizon and its azimuth (bearing from the north). This, together with a height independently ascertained, provides the parameters required for finding the speed of the wind at a particular height.

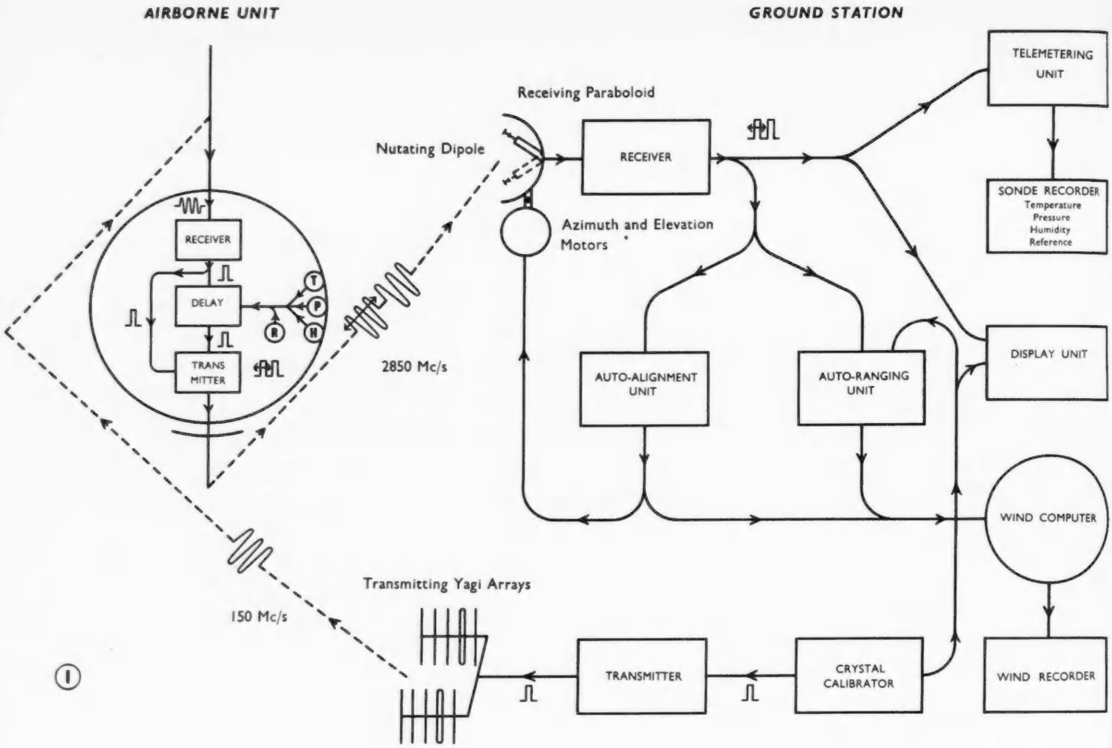
In Britain, with the release immediately after the war of suitable army radar equipment, the development of specialised wind-finding apparatus became unnecessary. These radar sets could accurately locate the balloon in space, there being no need to guess at, or independently ascertain, the height. A single ascent could be employed for the measurement of the pressure, temperature, and humidity as well as wind, or for wind-finding alone; but the two forms of observations were carried out independently except for the balloon used in common. The reliable "Kew" radio-sonde, the use of radar, careful attention to detail, and regularity of observations gained the British system a high reputation.

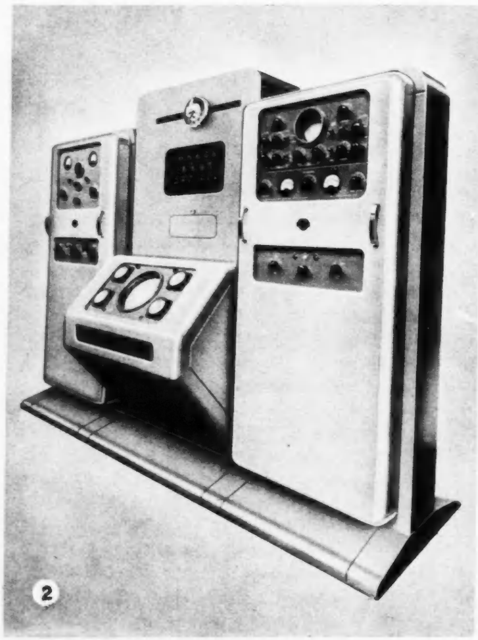
NEW INSTRUMENTS

No upper limit can be placed upon the height of the atmosphere that is significant in studying weather changes at lower levels. A variation of conditions at heights far beyond the reach of present-day instruments may cause alteration in the weather at the earth's surface. Aircraft of the future will operate at greatly increased heights; therefore the need for new apparatus has become an urgent practical necessity. It is desirable to obtain data from such levels before the designs of projected high-flying aircraft have been completed. The meteorological apparatus must be capable of supplying accurate information at regular intervals up to a height of at least 75,000 feet. The method of numerical forecasting now being developed will in no way lessen this demand for upper-air information. As a basis for numerical extrapolation, observations of the highest possible accuracy will be needed in those layers of the atmosphere selected for this type of examination.

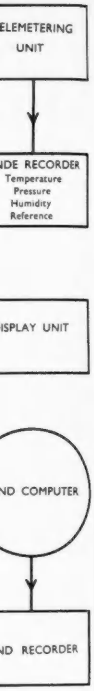
The need for new equipment capable of meeting the full demands both of height and accuracy for many years to come was foreseen some years ago by the Meteorological Office, and a careful examination of various methods of achieving the requirements was made by the Radar Research Establishment. A new system was evolved of transmitting the measurements of pressure, temperature and humidity from the airborne apparatus to the ground. Existing radar methods were adapted for very accurate wind-determination over long distances. A manufacturing firm was then asked to develop the method and construct trial equipment. It has now reached the stage of its final acceptance trials.

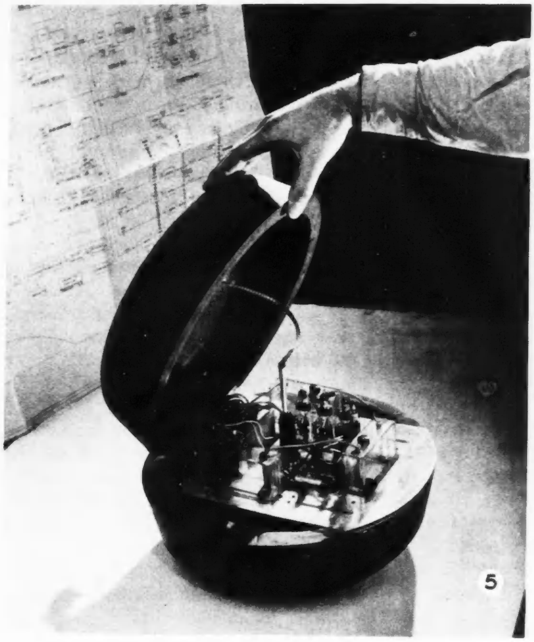
The basis of the new system, known as the "radar sonde theodolite" is the use of "secondary" radar. The existing radar employed in this country for wind finding depends upon observing, at readable strength, the echo of a pulse of radio energy. This pulse is transmitted from the ground station in a beam pointing in the direction of the balloon, and some of its energy is returned after being scattered and re-radiated by a suitable "radar target" carried by the balloon. The double journey involved, together with the losses due to scattering, results in much attenuation of the energy eventually returned to the ground station. Consequently the signal may become unreadable before the balloon has reached the limit of its ascent. A marked increase in the power of the emitted signal is not desirable, and thus the range of operation and the height to which winds could be measured is strictly limited. The secondary radar of the new system obviates the need for such increases of power by providing, instead of an airborne reflector, a "transponder" consisting of a radio receiver and transmitter combined in miniature light-weight form. The sequence of operations is that a pulse of radio energy, on a frequency of 152 megacycles, is transmitted by the


AIRBORNE UNIT
GROUND STATION
RECEIVER
DELAY
TRANS MITTER
T
P
H
R
2850 Mc/s
150 Mc/s
Receiving Paraboloid
Nutating Dipole
Azimuth and Elevation Motors
RECEIVER
TELEMETERING UNIT
SONDE RECORDER
Temperature
Pressure
Humidity
Reference
DISPLAY UNIT
AUTO-ALIGNMENT UNIT
AUTO-RANGING UNIT
WIND COMPUTER
Transmitting Yagi Arrays
TRANSMITTER
CRYSTAL CALIBRATOR
WIND RECORDER
1


2

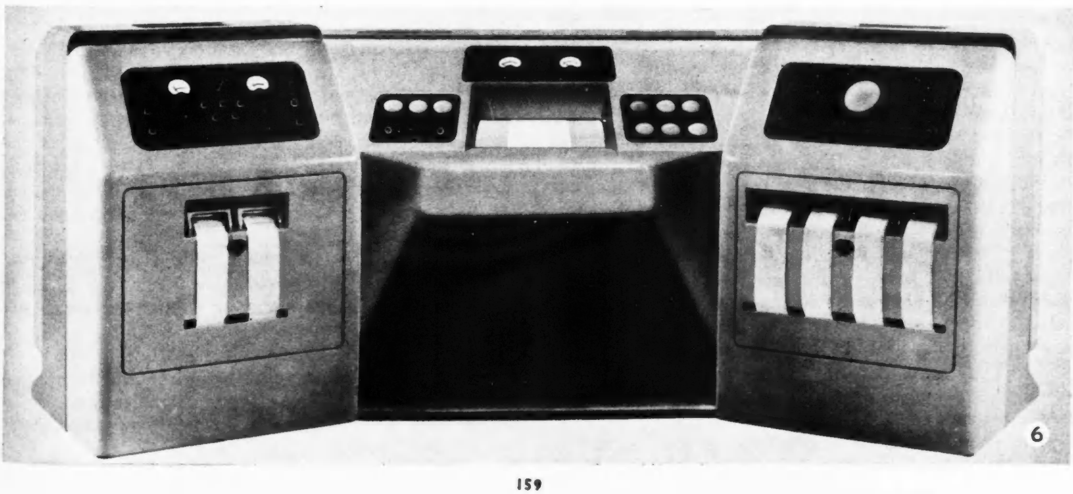

3





Since the start of the "Jet Age" the desire of meteorologists to obtain more accurate information up to greater heights of the atmosphere has become a matter of practical necessity. To meet this need Mullard Ltd. was asked to develop and contruct, in conjunction with the Ministry of Supply and the Meteorological Office, entirely new equipment, known as the Radar Sonde.

To make observations to heights greater than 80,000 ft., using apparatus carried by a balloon which might drift over 100 miles from its release point, a secondary radar system, shown diagramatically in Fig. 1, has been used. In this system strong directional radio signals, of pulse form, are emitted by the ground station transmitter and are received by the airborne transponder unit (Fig. 5). On receipt of this "questioning" signal the airborne unit replies by transmitting a complex signal from which can be derived all the information required, at each successive layer of the atmosphere. The radio transmitter and receiver of the ground station is built with a single unit (Fig. 2), while the aerial system (Fig. 4) is automatically directed towards the transponder, whatever the movement of the balloon as it ascends and drifts with the wind. The presentation of the results is also automatic. Wind direction is recorded as a trace, on circular graph paper, drawn by a rotating table (Fig. 3) which also houses the computing equipment. Wind speed, height of the balloon and atmospheric pressure, temperature and humidity appear at the main presentation console (Fig. 6) as continuous records. For greater accuracy the latter three values are given also in the form of printed figures.



ground station and is detected by the radio receiver unit carried by the balloon. This automatically activates the transmitter of the airborne unit, which responds by transmitting two separate radio pulses, each on a frequency of 9 centimetres, the first pulse being generated with a known, and very small, time delay after reception of the 152-megacycle pulse, and the second after a further variable time delay, determined by the readings of one or other of the meteorological measuring devices. Three meteorological instruments, sensitive respectively to pressure, temperature, and humidity, are provided; and each is connected in turn into the radio circuits to produce the appropriate value of time delay. A motor-driven switch is provided to make the necessary connexions and to repeat the cycle of measurements over and over again as the balloon ascends.

At the ground station the overall time interval between the initial transmitted pulse and the first of each pair received back from the airborne transponder, is measured and used to compute, at any moment, the distance of the balloon from the ground station. At the same time the aerials of the receiving equipment are automatically maintained in an attitude pointing directly at the balloon, as any failure in this respect would result in error signals which immediately drive the aerial into its correct position. This process is maintained continuously, pulses being exchanged at the rate of 400 per minute. As the balloon drifts and ascends, its movements are automatically followed by the aerial, and from the rates of change of range and of angles of elevation and azimuth, the wind at any given moment is continuously computed. This computation is made by an electronic wind "resolver" which also provides a height value and produces, in the form of graphs drawn as the balloon ascends, a continuous record of wind speed, wind direction, and height of the balloon, each indicated against a time reference.

The ground equipment also observes the time intervals measured in term of micro-seconds, between the pairs of pulses transmitted by the transponder. Although this time interval is controlled by one or other of the required meteorological values, the measurement of the interval between only one pair would not in itself provide the accuracy of measurement required. Therefore a series of 500 pairs of pulses are received and their mean value calculated by electronic equipment before the value is indicated in the form of printed figures and as a graph. The switching cycle of the airborne unit provides for the time interval of 500 consecutive pairs of pulses to be controlled by each of the three meteorological units in turn. It also interjects control signals between one form of meteorological measurement and the next. These ensure that the ground apparatus shall distinguish between the groups of pulses relating to pressure, temperature, humidity, and feed, each pulse going to its appropriate section of the equipment. Thus no confusion can arise between the values of the three meteorological measurements, each of which appears on its own graph.

The meteorological measuring device used for pressure readings consists of an aneroid box; this expands under reduced pressure and moves an armature towards an inductance coil, thus changing the time delay characteristics of the circuit. Humidity is similarly recorded, a small piece of gold-beater's skin producing the necessary mechanical movement. To measure temperature, a fine wire-resistance thermometer is placed directly in an appropriate circuit. Before flight each radar sonde unit is subjected to pressure, temperature, and humidity calibrations. A chart is then prepared showing the time delay corresponding to actual meteorological parameters.

Many difficulties were encountered in developing the new system, and some of these have not yet been fully overcome. At first it seemed that the height to which the apparatus would operate would be limited by the gas discharge and arcing which occurred at high-voltage points in the airborne transmitter at the low air pressures met with about 65,000 feet. By careful redesign of particular components the onset of such discharges has been delayed, so that a height of at least 75,000 feet can be achieved. Further height increases, to at least the 100,000-foot level, will undoubtedly be needed soon, but methods are being worked out for detailed modification of the radar sonde unit to keep pace with this increase.

The rate of sampling of pressure, temperature, and humidity achieved by the radar sonde has also proved somewhat disappointing so far, although with greater experience a more rapid rate may be achieved. At present the cycle of pressure, temperature, and humidity requires fifteen seconds to complete. If a balloon ascends at 1200 feet per minute, this results in a measurement of each element every 300 feet. Only one and a quarter seconds are actually required to complete each individual meteorological measurement, a total of three and three-quarters seconds being usefully employed per cycle in passing the meteorological information. The rest of the cycle is devoted to the control signals and to two additional reference measurements; these indicate changes in the calibrated values of the time delays arising from alterations within the radio circuits. The type of cheap and simple electric motor which is used does not guarantee a fixed speed; a tolerance is therefore given to the switching rate to ensure that even with the fastest motor each meteorological unit is in circuit for at least 500 pulses. Precautions, such as the provision of all possible references to indicate the behaviour of the radio circuits under varying temperature and pressure conditions, are wise in a new design, but may well prove unnecessary once experience has been gained.

Extensive operational trials of the equipment are likely to begin soon, to determine the overall accuracy of the equipment. During these trials a technique will be developed for extracting and reducing to actual meteorological values the more urgently required information for immediate transmission to the forecasting offices both of this country and those overseas. The graphs and tabulated values provided by the equipment will later be made available for research into the finer structure of the atmosphere.

ANNÉE GÉOPHYSIQUE INTERNATIONALE
1957 1958
INTERNATIONAL GEOPHYSICAL YEAR

THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

Planning and Organisation

The Bureau of ICSU (the International Council of Scientific Unions), the body that brought CSAGI into being and provides its finances, has appointed two additional members to the Bureau of CSAGI—Prof. V. V. Beloussov (Soviet Union) and Prof. J. Coulomb (France). It has also asked that a Finance Committee be constituted to be composed of the Treasurer of ICSU and two members of CSAGI who are not members of its Bureau. Dr V. Laursen and Dr A. H. Shapley have been appointed.

An Advisory Committee on Publications has been set up under the chairmanship of Dr D. C. Martin, Assistant Secretary of the Royal Society. Its other members are Col. G. Laclavère, Dr W. W. Atwood, Prof. V. V. Beloussov, Father J. O. Cardus, and Dr M. Nicolet (General Secretary). One of its immediate tasks is to prepare the publication of a journal, "The Annals of the International Geophysical Year", in which all IGY documents will be reproduced. The first volume will deal in general with the IGY programme and trace its derivation from the First and Second Polar Years. The Pergamon Press will produce the volumes, and the fifteen CSAGI reporters are being invited to join the Editorial Advisory Board of the "Annals". The text will be in French and English.

A regional conference to co-ordinate IGY plans for Africa south of the Sahara, took place at Bukavu, in the Belgian Congo, in February. A report on a tour made of the area by Dr S. P. Jackson formed the basis of the agenda.

A Western Pacific regional conference was held in Tokyo from February 25 to March 2.

Communications Network

The days between the 10th and 16th of each month this year have been used to test the efficiency of the IGY Communications Network on which so much depends, and which has been organised by WMO (the World Meteorological Organisation).

By the second month's trials the system was working to schedule. Messages sent at 16.00 hours from the IGY World Warning Centre at Fort Belvoir, Washington, D.C., were received in London within the half-hour. The route to Great Britain is: Fort Belvoir to New York by landline, New York to Paris to Dunstable by teleprinter. Alternatively, London might pick up the radio-teleprint signal put out at 16.12 hours from New York, direct.

The first trial alert took two hours twelve minutes to reach Britain. It arrived via Paris. The ends of the line are Tokyo and Canberra. Both these centres receive the signal from two directions, West-about (circulated from San Francisco) and East-about (circulated from New York).

Antarctic Notes

A full account of achievements of the Antarctic season just past, from October to March, should be ready for next month's issue. We hope these notes will suffice for the present.

Argentina: A new sub-Antarctic base has been established on Thule Island in the South Sandwich group, and the General Belgrano base on the Weddell Sea was afterwards relieved. The ships sailing from Argentina on this expedition were the large ice-breaker *General San Martin*, a transport, and two hydrographic ships. After relieving the Weddell Sea base, an extensive oceanographic cruise in this area was planned.

Australia: The *Kista Dan* finally reached Mawson on February 2, the expedition having first completed the building programme and unloaded a year's stores and equipment at the new Davis Base at Vestfold Hills, where a wintering party were left in occupation. Meantime, a party from Mawson under Bill Bewsher had been engaged for three months in exploring the recently discovered Prince Charles Mountains, 250 miles from the base. A Weasel and dog-teams were taken, but there was more crevassing at the foot of the mountains than had appeared from aerial reconnaissance; most of the travelling, therefore, had to be done by dog-sledge. The party got back to base about the same time as P. G. Law, Director of the Australian Antarctic Division, in *Kista Dan*, arrived from the outside world.

Britain: A suitable site for Depot 300, 270 miles into the interior from Shackleton, was located after considerable aerial reconnaissance of the mountainous area lying across the route South from Dr Fuchs' base on the Weddell Sea. The depot, now called South Ice, with a wintering staff of three men, was established by airlift on February 4.

Early in February an eleventh FIDS base, at Ferin Head, 66° S., 65° 24′ W., on the West coast of Grahamland, was established from the RRS *John Biscoe*, the new Antarctic ship whose first season this is. The base is to be called "Graham Coast Base", since it is one of the few stations that the Survey has been able to site on the mainland. Ten men will spend the winter there. The Grahamland aerial survey being carried out by Hunting Aerosurveys for the Governor of the Falkland Islands is proceeding well, though the party was unlucky enough to lose its helicopter at the beginning of the season. This year the survey has two aircraft, and the weather has been kinder, so that on their first flying day this season they photographed as much as in the whole of last year's expedition.

Chile: The base-relieving expedition sailed for home on January 21, having completed its mission to the stations off the Grahamland peninsula.

Japan: The expedition under Prof. Takesi Nagata, the eminent geophysicist, landed on Ongul Island on January 26.

A party of men were left behind for the coming winter. The *Soya* was beset but was released with the aid of the Russian ship *Ob*.

Norway: On January 21 the party under Dr Sigurd Helle, an experienced polar explorer and the assistant of Prof. Stormer of aurora fame, left their base at a point thirty kilometres from the ice edge. Two ships, *Polarbjorn* and *Polarsirkel*, were used to convey the fourteen men and their equipment.

New Zealand: After Sir Edmund Hillary's plan had miscarried, due to the slushy ice surface on the Ferrar Glacier, another and preferable route was found on to the Polar Plateau via the Skelton Glacier. A base has been established at the head of the glacier route down which Fuchs' party will descend at the end of their trans-Antarctic crossing next year. It is at 7500 feet, and 260 sledging miles from Scott Base on the shores of the Ross Sea, the end of the journey. In early February Sir Edmund visited the plateau camp, accompanied by M. Paul Emile Victor, the French explorer.

In January the joint New Zealand-United States IGY base, at one time to be called Adare Base, was set up on a four-acre beachhead close to Cape Hallett, which is some distance farther along the Ross Sea coast.

U.S.A.: A ceremony to inaugurate the South Pole station, which had several times been postponed, eventually took place on January 24. In the presence of representatives of Great Britain and Norway, the base was named the

"Amundsen-Scott Base", in commemoration of the leaders of the first two expeditions to reach the Pole. They are, indeed, the only men to have set foot there until last November's landing by the Americans.

The base, off the Knox Coast, was finally established by the ill-fated *Northwind* in February. The ship also landed five Australian scientists who were to establish an automatic weather-station on the Windmill Islands (in the same area) and be picked up later on by the *Kista Dan* when she had completed her programme.

After a persistent tussle with the ice off the western end of the Filchner Ice Shelf, the *Staten Island* was commanded to withdraw, but in the end Capt. Finn Ronne obtained permission to set up his base close to Shackleton at the south-eastern corner of the Weddell Sea.

U.S.S.R.: Forty pigs are now thriving at Mirny on eight tons of imported Russian soil.

News from the Arctic

The seventh Arctic drifting station, North-Pole-7, is now being set up by Soviet scientists on ice-floes at latitude 85° N. A complement of forty research workers is scheduled. Results obtained from this station should be of particular value to IGY researches, since its course of drift is expected to be the same as that of N-P-3, which was in operation during 1954, a period near sunspot minimum. Direct comparison should therefore be possible with this year's readings reflecting the variations associated with sunspot maximum.

The staff of N-P-6, which set up the station in April 1956 in the region of Wrangel Island, has been relieved after a year's duty. The programme of both N-Ps 6 and 7 are concentrated on IGY work; measurements include those of the ionosphere, terrestrial magnetism, aurora, oceanography, and meteorology (aerological and actinometric, as well as surface measurements).

This month, N-P-4 celebrates its third year of existence, and a "voyage" through the ice of the Central Polar basin, unique in the history of Polar exploration. It was established in April 1954, some 300 miles north of Wrangel Island, and for two years drifted near the boundary of the Eastern and Western hemispheres, 180°. It crossed the submerged Lomonosov Range, and approached the mathematical North Pole. This amounted to a total distance for the drift of 4000 miles. Last January, when the station had been drifting for 1000 days, it lay near 88° N., one of the least known regions of the Arctic.

The Fall-out that does not Fall

With the working group meeting at Utrecht in January, the study of nuclear radiation in the atmosphere at ground-level has been established as part of IGY activities (*see* DISCOVERY, Dec., p. 523). For this achievement Dr W. Bleeker, the Dutch meteorologist who was chairman of the meeting, is largely responsible. The value of what is to be done might have been prejudiced if some of the more ambitious proposals (such as the widespread use, as atmospheric tracers, of radioactive material, with a half-life of twelve years or more) had been encouraged.

The main recommendations ask for two sorts of sampling to be carried out at ground-level in association with aerological measurements; the desirable distribution of sampling stations is therefore one station per 100,000 square kilometres of the Earth's surface. This includes sea areas, and is the minimum network adopted for radio-sonde measurements. Sampling will be directed to the study of nuclear radiation deposited on the Earth's surface (most of it in rainwater). Another sample, which will be carried out daily by exposing filter-papers of sufficiently fine grain to catch particles down to 0·00002 of a centimetre in diameter, will indicate the nuclear radiation suspended in the atmosphere. By subtracting the amount of radioactivity detected in the one observation from that found in the other, a rough guide to the volume of radiation that is *not* washed out of the atmosphere by rain should result. Work so far done on this problem suggests that, when it rains, about ten times more atmospheric radioactivity is deposited on the Earth's surface than in dry weather.

The reduction of the air samples can be carried out at the sampling stations, but analysis presents an organisational problem. It is recommended that polyethylene containers are left outside for a month, at the end of which time one litre of the contents is to be drawn off and sent to a suitable laboratory for analysis. It is also proposed to build up a collection or "library" of analysed samples for permanent reference.

One of the difficulties in determining the amount of potential harm from radioactive fall-out being caused by the explosion of nuclear bombs is that "fall-out" is itself a misleading term. A certain amount of radioactive debris remains suspended in the atmosphere and may travel round and round the globe for years before being deposited. The proposed IGY measurements will take a step towards answering the questions "How much?" and "For how long?"

Another difficulty is that the level of surface radioactivity was not known before the first atom-bomb exploded, so that it is impossible to judge by what factor radioactivity has increased above the natural level. The Utrecht meeting considered an ingenious means of getting over this difficulty, by analysing the radioactivity trapped in the annular bands that occur in glaciers, the result of each year's unmelted accumulation of snow. These bands can sometimes be traced back accurately for forty or fifty years. If measurements of the radioactivity of bands from the "pre-atomic years" prove feasible, these will be a guide to the level of natural nuclear radiation. Unfortunately, there was no glaciologist at the meeting but specialist advice is being sought.

Meteorologists are very interested in these measurements, for the tracking of the air's radioactivity would give them a convenient probe for atmospheric circulation patterns. The study of seaborne radioactivity may also prove a short cut to understanding the mixing of the sea—a primary concern of oceanographers.

Sixteen countries were represented at the meeting; a delegation of nine came from the United States. Mr P. J. Meade of the Meteorological Office, who is a member of WMO Panel of Experts on atmospheric radioactivity, attended on behalf of Britain. Though there was a preponderance of meteorologists present, other delegates were drawn from among nuclear physicists, nuclear chemists, and oceanographers.

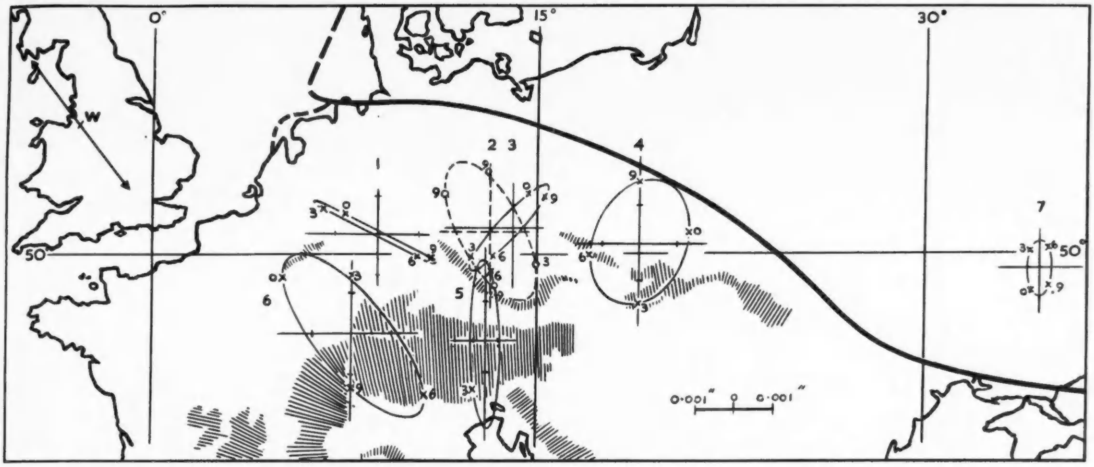
Two Magnetic "Norths"?

On one of the final proving flights (in February) for the new Scandinavian Airlines System's transpolar route to Tokyo, a team, led by Dr Arne Eld Sandström of Upsala University, flew a quarter of a ton of specially designed cosmic-ray apparatus over the Pole and back via the Tropics.

Information on cosmic-ray intensity in polar regions generally is sparse; but no measurements have ever been made at all above 75° N., much less over the Pole itself. The DC-7C aircraft travelled most of the way above 20,000 feet. This gave the observations additional value, since the higher cosmic rays can be intercepted the more information they can be made to convey. The staging-point from Scandinavia to Tokyo is Anchorage, in Alaska; this took the flight directly over the North Pole, but also brought it very close to Magnetic North, which for this work was quite as important.

A suggestion first put forward some eighteen months ago by Dr J. A. Simpson, of Chicago University, and Dr D. C. Rose, the Canadian physicist, and which is occupying a good deal of attention from cosmic-ray specialists, requires a volume of measurements of cosmic-ray intensity from polar regions and also at the Equator, for its confirmation or rejection. These scientists' observations suggested to them, broadly, that besides there being a geographic and a magnetic North, there might be yet another, the "cosmic-ray pole", for want of a better name. It seemed that the direction of the Earth's magnetic field at the globe's surface did not coincide with that high above the atmosphere, where the field operates on incoming particles. Indeed, at some places the poles appeared to be displaced by as much as 40°.

It is known that cosmic rays, as they approach the Earth from outside the



Uniformly reduced residual M_2-tilts on the European continent. Thick line shows approximate direction of border of the Baltic Shield. Tectonic influences on tidal residual movements are shown. (*Reproduced by kind permission from "Nature"*, 1954, vol. 173, p. 143.)

atmosphere, are affected, perhaps hundreds of miles above the surface, by the Earth's magnetic field of force like iron filings by a magnet. By observing the way in which the concentration of cosmic rays varies from the Poles to Equator, a measure can be had of the possible displacement of the Earth's magnetic field at the surface and in space.

Last autumn (*see* DISCOVERY, Nov., p. 481) Dr Simpson conducted a number of crossings of the cosmic-ray Equator from a fleet of U.S. Air Force bombers. A preliminary report of his measurements seems to confirm his displacement theory, but his calculations are not yet complete. Dr Sandström's research on the SAS pioneering flight over the Pole and his return via the Tropics, which will enable a wide range of latitudes to be screened for varying cosmic radiation at about the same height on the same instrument within a short interval, will provide further material for this fundamental inquiry.

Miss Pamela Rothwell, of Imperial College cosmic-ray laboratory, also in search of data of this kind, has lately completed a round-Africa investigation of cosmic-day intensity using a neutron pile monitor installed on board SS *Roxburgh Castle* of the Union Castle Line.

The instrument used by Dr Sandström on the polar flight was a neutron monitor with a counting rate of 400 c/min., recently developed at Upsala. The readings can be automatically filmed. Dr Sandström is prepared to exchange data with interested scientists in advance of the scheduled IGY date, and has material from last September onwards ready for distribution.

Tides that Move beneath our Feet

Researches that have gone on for a number of years in this country, on the Continent, in Russia, and in the United States, and that will be extended during 1957–8, suggest a concept of the globe beneath our feet as a huge elastic ball. It appears that even the increase or reduction of atmospheric pressure depresses or stretches the Earth's skin, and in maritime districts the weight of the sea at high tide produces even bigger changes. Over longer periods, a general adjustment of the Earth's crust at the turn of the season becomes apparent. It may be said that the Earth is a different shape in summer from what it is in winter.

Dr R. Tomaschek, an authority on this subject who has conducted a number of earth-tide experiments in Britain through the British Petroleum Oil Company's Research Centre and has others in view for the IGY period, contributes the following note on the measurement of earth-tides.

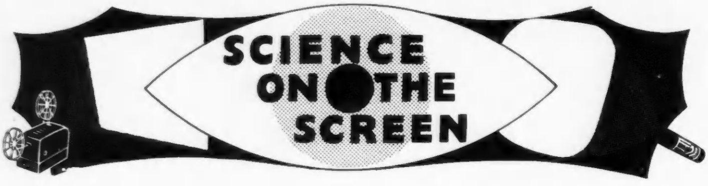
World-wide contributions are expected during the IGY to the problem of the tides of the solid Earth. Under the influence of the gravitational forces of the Moon and the Sun, the solid Earth undergoes a tidal movement comparable to that of the sea tides. Because of its elasticity the solid Earth yields to these forces, and each point of its surface is undergoing an up-and-down movement twice a day with the main period of about twenty-five hours. Neap and spring tides as in the sea may be detected also, and are caused by the interaction of the lunar and solar cycle. The amplitude of this movement is not yet exactly known but it is estimated to be of the order of about $\pm$ 20 cm.

As this elastic tidal deformation depends on the density, elasticity, and rigidity of the Earth's interior, the knowledge of its exact amount gives information on the Earth's structure and this is one of the main objects of the observations planned for the IGY. The measurement of these up-and-down movements has shown, furthermore, that additional movements exist due to the load from the sea tides, especially in and near maritime regions such as the British Isles, and also from the load of meteorological pressure-fields as shown by the cyclones and anticyclones of the weather charts. The tectonic structure of the region under observation is also an important factor. By correlated observations of these variables, information on the elasticity of the Earth's crust and its constitution by different coherent blocs are expected.

The instruments used in detecting these effects are gravimeters for the vertical up-and-down movement, and horizontal pendulums for measuring the tilt movements connected with it. The gravimeter uses the extension of a helical spring by an attached mass. Increase in gravity increases the weight and with it the length of the spring, and although the effects are of the order of magnitude of only one hundred millionth of normal gravity, modern instruments are capable of registering these variations without being unduly affected by temperature.

The horizontal pendulums work according to the principle of a door whose hinges are not quite in a vertical line and which will therefore always stay open at a certain angle. If the part where the hinges are fixed is tilted a little, the door responds by a large angle of movement, making visible in this way even extremely small changes in tilt. The modern horizontal pendulums consist of a mass fixed to a rod which can swing horizontally by being held by two thin metal strips. They are able to respond to tilts of the order of a ten-thousandth-of-a-second-of-arc, the magnitude of earth-tide movements.

During the IGY about fifteen stations will operate on the European Continent and two or three in Great Britain. Approximately the same number of stations is expected to be distributed over the rest of the Earth's surface including within the Tropics.



Man in Space

A Walt Disney Cartoon. 35 mm. (possibly later 16 mm.). Colour. 33 minutes. Technical advisers: Drs W. von Braun, H. Haber, and W. Ley.

There is compensation for the economic and political uncertainties, as they seem, of the 20th century. The progress of technology, at least, can be forecast with tolerable certainty. "Man in Space" is an essay into this field of prediction with its strange blend of values, part factual, part fictional. Coming just before our first artificial satellites are supposed to trace their flying pin-points through the heavens, this film will do much to help the non-scientist participate in tomorrow's adventure.

After an introduction to the subject by Disney himself, the film deals with the past, going back to the rocket's presumed invention by the Chinese in the 12th century. (But they are not given due credit for their prompt conclusion that gunpowder was best kept for fireworks.) Conjecture and cartoon combine effectively and lead naturally to the theory of rocket propulsion; those interested in bringing science to the citizen can here be fascinated by good exposition, and by the spectacle of Newton's Third Law of Motion at least making a bid for popular acclaim on the screen.

In the modern historical period, actual cinematographic records support the story. But the first item reminds us of that perplexing blend of fact and fancy which is always just round the corner. An early "space fiction" film, Georges Méliès' "Voyage dans la Lune", shows a bevy of Edwardian stage cuties waving farewell to a rail-launched rocket to the Moon; its disastrous landing, in the Man-in-the-Moon's right eye, brings us back to reality.

Rocket work with rail-cars, gliders, and even winged bicycles, is a witness to the enterprise of such pioneers as Opel—not to mention their cinematographers! This is necessarily a condensed popular account of rocket experiments and does not mention the fundamental inefficiency of the rocket for propulsion in an atmosphere. Reference is made to the German "Society for Space Travel", which became involved with missile development before and during the Second World War. From the many V-2s later taken to the U.S.A. came some of the foundations for the well-known American rocket types, Viking, Corporal, Aerobee.

Animation is used throughout the rest of the film to present the theory and practice of rocketry. The need for multiple-stage rockets is explained, together with the essentials for setting up an orbital satellite. The exposition appears simple, but, in fact, the whole resources of music, colour, and graphics skilfully put over information which ten years ago would hardly have found its way into an entertainment cinema.

Besides physical, there are biological problems. The essence of space medicine is expounded by an amiable little cartoon figure, a "statistical man" called *Homo sapiens extraterrestrialis*, who extracts both information and humour from such activities as decanting a weightless dry martini and smoking a cigar in a non-convective atmosphere. His survival of multi-*g* pressure, cosmic ray dosage, and meteor puncture, is also discussed.

The film ends with the first manned flight to outer space. There is the concentrated, but efficiently unhurried drill of preparation, the dramatic counting down to firing-time, all the activity which has been much handled in science fiction films. This skims the cream from the best of them—indeed, the skimming is a little over-fine, for rather than dwell on interesting technical details after the launch, the editing tempo stays on the fast side. Perhaps this helps to gloss over the problem of space navigation, considered by some to be a vastly complex matter, and possibly the greatest obstacle to space travel. Exhausted stages of the rocket are jettisoned, the crew takes up watch. From the starry darkness there swings majestically into view the unmanned satellite dispatched some years earlier; it continues in its orbit, passing from our ken.

"Man in Space" speaks authoritatively upon the first, physical, problem of space-flight, and it usefully discusses the second, biological, problem. But it says nothing about the third problem.

The third problem is the social one. Can a large enough group muster the technical facilities to produce a manned space-rocket weighing several tons? The now-building Earth satellite is a mere instrument-carrier weighing but a few pounds, and expendable at that. Yet its cost is enormous and seems only within the range of groups as economically massive as the U.S.A. and the U.S.S.R. (National prestige being what it is, others would launch "their" satellites if they could afford it.) What group could foot a bill at least several thousand times heavier? Even allowing for the greatest economic advances, a large measure of international collaboration seems a first essential. Perhaps the solution of this third problem lies with audiences who see the film.

GEOFFREY BELL

Mirror in the Sky

Sponsored by Mullard Ltd and distributed by Educational Foundation for Visual Aids. Producer, Basil Wright. Director, Alex Strasser. Commentary by Ritchie Calder. 16 mm. 35 minutes.

"Mirror in the Sky" is the imaginative title for a film which has been sponsored by Mullard Limited in co-operation with the Educational Foundation for Visual Aids. It deals, as a sub-title points out, with "the story of Appleton and the Ionosphere" and is Britain's contribution to a series of films on "the history of modern science", which countries of the Western European Union has agreed to prepare. It is a worthy contribution, free from any obvious flag wagging, yet clearly showing what British science has achieved in a problem of international interest. But there is more behind the film than graphic illustration of some aspects of British science. We are today in sore need of more technologists, more applied scientists, and more men and women to tackle the problems of fundamental research. We need forcibly to show that science is neither a bogey nor magic under a new guise, but an adventure in fitting our observations of nature into a coherent scheme. In doing so we need to appeal to the imagination of young people, to those of the thirteen–fourteen year age-group, so that they get some idea of this adventure and are stimulated to take up this vitally important calling. That such an imaginative appeal can be made without a distortion of the facts is clearly shown in "Mirror in the Sky".

The film opens with a scene where Marconi's receipt of radio waves across the Atlantic is dramatically (but not over-dramatically) portrayed. This poses the problem: how do radio waves travel? The experiments of Hertz (using his original apparatus) are vividly shown, Heaviside's theory of a reflecting layer is explained, and the film leads on quite naturally to Appleton's experimental investigation. To understand Appleton's experiments we need an appreciation of the phenomenon of interference, and here the film reaches a peak of brilliance. The medium of the cinema is ideal for describing in graphic form such phenomena, and the director, Alex Strasser, has used his opportunity with singular success. The effect of solar radiation on the ionosphere is also excellently shown and, whatever may be the inadequacy of contemporary theories of the nature of electromagnetic radiation, it is a pleasure to see this radiation illustrated as little "packets" of waves instead of a continuous wave disturbance. Pulse

technique is shown and its application to radar as well as to obtaining echoes from the moon and from meteors illustrated; thus we see the various kinds of application which have resulted from a theoretical and experimental technique. Ionospheric observing stations and their influence on weather prediction is graphically shown, and the film ends with a visual peroration on radio astronomy.

Sir Edward Appleton appears in his "proper context" (if one may use such a phrase), and there is throughout a really correct use of the screen as a dynamic medium of communication. It is, therefore, sad to have to catalogue three errors. These occur in the astronomy sequences at the end of the film. First we are told that some radiation is received from star clusters, but at the same time a beautiful photograph of the spiral nebula in *Canes Venatici* appears on the screen; this does seem a piece of mis-information which could easily have been avoided, especially as a globular cluster appears later in the film. Secondly we are given, quite properly, an indication of the vast distance of the galaxies by remarks on the time taken by the light from them to reach us; in one case two hundred million years is mentioned, but with the added explanation that it set out on its journey "before there was life on earth"; recent views give an age of the order of eight hundred million years, so once again we have a remark which surely should have been corrected. Finally, it is unfortunate that the impression should be given that the sources of radio radiation in space are "dark" stars. Recent research indicates that much, if not all, is emitted from turbulent gas, which of course exists not only on the stars but also, and most in evidence, within the vast nebulous clouds of the galaxies themselves.

These minor errors do not, however, detract from the quality of this excellent film which should be seen by the widest possible audience.

C. A. RONAN

Milling and Smelting the Sudbury Nickel Ores

Colour. Sound. 16 mm. 54 minutes. Made by Film Graphics, New York. Available from Mond Nickel Company Ltd, Millbank, London, S.W.1.

This is the second of the series of films made by the International Nickel Company of Canada dealing in great detail with the whole process of nickel extraction and purification. The first of the series was reviewed seven months ago (DISCOVERY, 1956, vol. 17, p. 393), and severely criticised, because the producer addressed himself to a general audience, whereas the film was only suitable to a highly specialised audience of mining engineers and students of the subject. In this second film the appeal is directed to this technical audience, and it will not fail to captivate them. Neither money nor effort has been spared in this luxury film production to present a clear and concise exposition of the many stages of nickel smelting and ore separation processes which are necessary to produce the final concentrates. Differential flotation separation of nickel-, copper-, and iron-sulphides, the roasting of the sulphides in reverberatory furnaces, the Bessemer process of oxidation, the nickel-sulphide magnetic separation, the unique oxygen flash smelting furnace, and the electric arc furnace are explained by detailed animation cinematography, and beautifully illustrated by excellent colour sequences which must have demanded from the cameraman infinite skill in lighting and a great feeling for the subject. The men behind the processes are not forgotten and often figure as the minute genii behind the giant machines. In a few places a tactful use of music and of natural sound enhances the effect. If the further films of this series come up to the same high standard of production, then mining engineers will be fortunate to have a singularly complete and clear film treatment of one of man's great achievements of the 20th century, the mass production of nickel.

A. R. MICHAELIS

Television

Science, even in the broadest meaning of the word, is being let off rather lightly by television just now: a fact to which the *Spectator* drew attention recently. In the first five weeks of 1957 there were two programmes in the BBC's monthly series, "A Question of Science"—the only programme in which the BBC officially recognised science in the title. There was also a series of five programmes on "The Hurt Mind"; a weekly series called "Travellers' Tales"; an excerpt from Disney's excellent film, "Men in Space", in "Panorama"; a Press Conference on atomic energy; and the occasional Peter Scott programme, "Look"; and "Animal, Vegetable, Mineral?"

On Independent Television during the first six weeks of this year there was nothing at all that could be remotely called scientific. On February 18 the first ITV science programme, in a new half-hourly series, was broadcast at the rather useless hour of 6 p.m.—during the reprieved "toddlers' truce". As a consequence, I was unable to see it—as will be the case with future programmes if they are kept to this time. This first programme is believed to have been quite good—but why put it on when millions of breadwinners are in the train for home, while housewives are either bathing the kids or preparing the supper? Older children—or such as are not doing homework—will be the main group to benefit.

For its most recent series, "A Question of Science" has as its chairman Stephen Black, whose playful *bonhomie* is a little trying. The series is based on the answering of questions sent in by viewers. In the first programme, there was one item about shattering wine-glasses by singing high notes. The rest of the programme included the classic high-speed shot of a drop of milk splashing into milk; a film on the working of vocal chords; an inconclusive answer to the question, "What is double-jointedness?" and a hurried item on fire-eating.

In the second programme, Arthur Garratt showed us the strains produced in glasses during manufacture, using polarised light, and gave a good account of the toughened glass used in car windscreens. A doctor told how he kept warm during an Arctic expedition. The danger of beating frost-bitten fingers to restore circulation was demonstrated by freezing a lump of raw steak in liquid air and then smashing it with a hammer. A simple and clear account of "table-top" animation by Norman McQueen was followed by a talk on concussion from an RAF doctor from the Institute of Aviation Medicine at Farnborough. The programme again petered out with a rather weak item on the breast-pocket receiver method of alerting doctors in hospitals.

Generally speaking, the level and style of "A Question of Science" are those of first-year school science—which is, perhaps, as it should be. Demonstrations are, on the whole, quite entertaining; some of the animation and special effects are not bad. It is a beginning.

"The Hurt Mind" was certainly an important and excellent series and for millions of viewers must have answered many doubts and questions about mental illness. Per Høst's "Travellers' Tales" films are on the borderline of science. Lapland, bird life on Lofoten, Galapagos — ornithologists especially should find these programmes valuable; and also Peter Scott's film of his visit to Conrad Lorenz's Institute of Animal Behaviour in Bavaria. Such programmes are straightforward and honest and bring to viewers new facts about nature, with occasional glimpses into ecology and other fields of science.

But this is surely not enough in an age when science is entering more and more into everybody's lives. Maybe science isn't "popular entertainment"; maybe television is supposed to be just that. But surely neither statement is entirely true, and certainly those who control television seem not over-anxious to give science a chance to prove its potential popularity. It is almost as though they were afraid to try and break down the supposed resistance of the man-in-the-street (or man-by-the-fireside) towards science. But in other fields television is obviously attempting something more serious than entertainment; such programmes as "Press Conference", "Panorama", and the more serious documentaries show an awareness of responsibility towards influencing public opinion. Why, then, does television not do the same for science and try to place the methods and mean-

ing of science within the contemporary scene?

This can be done. "A Question of Science" at its best (but only at its best) points towards one way of doing it. But more programme time is the first requirement. In the meantime, the Peter Scotts, Per Høsts, and David Attenboroughs are filling in their own quiet corner of science, and doing it admirably.

DENIS SEGALLER

Ten Years of TV Inventors' Club

In April this year the TV Inventors' Club enters its tenth year of existence, and during this time the organisers have examined some fifteen thousand inventions, have selected nearly seven hundred for showing to viewers, and have had the satisfaction of seeing a quarter of those shown taken up by manufacturers.

Before Inventors' Club began, there were tens of thousands of small inventors all over Great Britain who felt they were struggling in an unkind world. They had heard or read of poverty-stricken inventors being robbed by greedy and unscrupulous manufacturers. They were afraid to disclose their ideas even to their closest friends, lest some unguarded remark should reveal their secret to the world, to be snatched up and exploited by others. Some of them spent years of their time and hundreds of pounds of their money developing prototypes which were hidden away in attics or workrooms. The inventors either did not know how, or were too scared, to take steps to protect and develop their own creations. Those who plucked up sufficient courage to approach a manufacturer were often put off by the difficulties of obtaining a personal interview with the right man who could understand their ideas, and encourage their development.

Now anybody with a worth-while invention can submit it in confidence and without charge to the BBC Inventors' Club.

What sort of people are these inventors? They come from every walk of life: banks, offices, factories, farms, ships, shops, Government Departments, local authorities. There are men and women, veterans in their eighties, schoolboys, baronets, knights, and dustmen. They are not the long-haired, untidy, distracted characters that the cartoonists would have us believe. They have proved, with rare exceptions, to be sensible, businesslike, and neat, the kind of people you meet in the street every day.

Some of the inventions these people submit have already been thought of. Others are impracticable or unmarketable. Still others are unsuitable for showing on television. Some look promising on paper, but can only be properly assessed when an actual working model is seen. Previews are therefore arranged, at which the inventors demonstrate their models, answer questions, and amplify the written descriptions previously submitted. Casualties at these previews are heavy, and the inventions left for actual showing on TV are less than 10% of those originally submitted.

Every kind of invention is eligible provided it is not intended for warfare or destruction. One of the most successful was Mr R. H. Evans's self-set mousetrap. Having been plagued with mice and rats when he was engaged in some important research work, and having been unable to get rid of them with the conventional snap-back mousetrap, Mr Evans set himself to study the habits of the mouse. He discovered that the mouse does not reach up and press down on the platform holding the bait, but, being a rodent, tears it outwards and upwards. So he reversed the mechanism of the trap, placing the bait beneath the platform and arranging for it to go off when the platform was pushed upwards. As a result he was able to rid himself of all his mice. His self-set mousetrap, made entirely in metal, was immediately successful in the shops, and two million have since been sold.

We have all seen the primitive gear used during the berthing of ships in the harbours. Thick knotted ropes, old car tyres, large chunks of cork, and similar odds and ends are lowered between the ship and the harbour side, to soften the impact and prevent damage to its sides. Captain A. J. Tweddell produced a "fender" consisting of sandwiches of rubber and other compressible materials, which would take the impact and pressure of large ocean-going liners, even in the roughest conditions. In the programme a 35,000-ton liner was shown being smoothly and successfully berthed. Now Captain Tweddell is making and selling his fenders both in this country and for harbours overseas.

A third example was Mr H. M. Bickle's tube sleeve. This arose out of an earlier invention, a hand-cream for removing dirt and grease from your hands if you were caught out anywhere without soap, water, and towel. You merely squeezed some of this cream on your hands, went through the motions of washing, held them up to dry for a few seconds, and then rubbed them together, when all the dirt came off in small pellets, leaving the hands clean and smooth. Mr Bickle quickly realised that the ordinary metal tube was not good enough for his cream, as it cannot be carried about in car cubby-holes, men's pockets, or women's handbags, without getting bent and cracked and leaky. So he designed a tube sleeve which would fit over the metal tube and protect it with an air cushion. Having succeeded in this, and finding the metal tube manufacturers reluctant to take it up, he invented a machine with which to make the new kind of tube. This is proving successful, and companies who use quantities of tubes for face-creams, and the like, have adopted the Bickle tube.

Another industrial example was Mr E. Cookson's "geartight union". In the many industries which use pipes, there are maintenance difficulties where the pipes run through almost inaccessible places, and if there is a leak or a burst it may be necessary to cut away a hefty section of pipe to do the repair. The geartight union, which, as its name implies, is a union or joint which is closed or opened by geared wheels, makes it possible to carry out repairs with simple tools, even in the most cramped conditions. After Mr Cookson had demonstrated it on TV he received many inquiries from large industries both at home and abroad.

Mr C. J. Rice's square-hole shovel, in conjunction with his post and timber driver, cuts down the cost of digging holes and planting posts. A job that takes two men with pick and shovel can be done more quickly and efficiently by one man. Moreover, as the hole made by pick and shovel has a wide top, while the square-hole shovel is uniform throughout, a third less cement is needed when planting the posts. Mr Rice received £20,000 from a London firm for this invention.

As an extension of its activities, the Inventors' Club has organised public showings at Selfridge's and the BIF at Olympia, and also instituted the Inventors' Award to the value of £200, open to all inventors in the Commonwealth.

LESLIE HARDERN

Rockets and Space Flight

(Film strip.) Edited by L. J. Carter, A.C.I.S. Published by the British Interplanetary Society, 12 Bessborough Gardens, S.W.1. 50 frames.

This compilation will be useful to anyone giving addresses on interplanetary affairs to audiences already interested in the subject. About a third of the black-and-white stills are of rockets or diagrams of these, and rocket-assisted military aircraft, while a half-dozen each of rocket launches, artificial satellite drawings, scenes of bodies of the solar system, make up most of the remainder.

Fairly full captions are given on the two double-sided close-typed duplicated sheets, but the lecturer is left to make his own connected thread to his discourse.

It would be an advantage if the satellites, mentioned in the captions, were shown along with their parent planets; but the anti-*g* suit, and scenes from the film, "Destination Moon", will no doubt do most to catch the eye of youthful audiences.

G. B.

Films in the Service of Industry

A Festival of Films in the Service of Industry is to be held in Harrogate from October 8 to 12, 1957, under the Presidency of Lord Godber and with the support of the Federation of British Industries, the British Employers' Confederation, the British Film Academy,

and other interested bodies. The Association of Specialised Film Producers have made their offices and staff available for the organisation of the Festival, and the Mayor and Corporation of Harrogate are providing accommodation and other amenities.

The aims are to assist in a wider understanding of what films can do for industry; to show how industry can use films for training, productivity, human relations, sales promotion, health, and safety; to improve the quality of industrial films and the way in which they are used. A selection of the latest and best industrial films produced in this country will be screened, together with a number of industrial films from overseas. Before the Festival itself, papers will be prepared on various aspects of the cinema in industry, and these will serve as a basis for discussion. Awards will be made for the best films in various categories, including public relations, sales promotion, training in industry, technology, films for schools, health and safety in industry, guidance on careers, industrial, productivity, human relations. Films will be judged not on the artistic and technical excellence of the film as such, but rather on their fitness for their purpose. Application forms for entering films for the Festival can be obtained from the Organising Secretary, 3 Portman Chambers, 8–9 Baker Street, London, W.1.

Adventure On

Producer, G. E. Sumner; Director-Cameraman, Tom Stobart; Editor, Terry Trench; Music, Brian Easdale; Orchestra, Sifonia of London. Running Time: 62 minutes. Print by Technicolor. In general only 16 mm. prints will be available. In exceptional circumstances, however, a 35 mm. print might be offered. For particulars concerning availability of prints, please apply to Massey-Harris-Ferguson, Fletchamstead Highway, Coventry.

Massey-Harris-Ferguson are to be congratulated for their imagination in sponsoring a film on the world-wide development of mechanisation in agriculture and its contribution to the well-being of whole areas and populations. The same cannot be said about the makers of the film.

To make "Adventure On" (a somewhat confusing title), Tom Stobart, as director-cameraman, travelled 57,000 miles through five continents. The film is in the form of a personal report.

It opens somewhat artificially with Stobart, presumably on the slopes of Everest, being asked by radio to make this film; thereafter we move through a patchwork of unrelated sequences and filmed interviews, interspersed with bits of native dancing. The film never comes to grips with its subject. It cannot be said that the technical quality of the film atones for its other failings.

GEORGE NOORDHOF

International Film Award

At the recent Film Festival held in Salerno (Italy) a Pfizer Medical film, "The Broncho-Pulmonary Segments", won the silver cup presented by the Order of Physicians for the best film in the scientific class. "The Broncho-Pulmonary Segments" is a coloured sound film, 16 mm., and 31 minutes long. Until recently it was sufficient to know merely the five lobes of the lungs. Newer achievements in diagnosis and therapy have, however, required a smaller and more accurate unit of localisation than the lobe. This need has led to the recognition of the broncho-pulmonary segments as anatomical entities. The film is an exciting exploration of these, using both a living organism and ingenious plastic models.

Requests for the loan of this and other Pfizer medical, veterinary, and agricultural films should be addressed to: Public Relations Officer, Pfizer Ltd, Folkestone, Kent. Many of the films are available with sound-tracks in the main European languages. Although Pfizer films are made primarily as teaching aids in medical schools, nurses' training departments, etc., they are also lent, according to availability, to scientific film societies. A few of the films are also suitable for showing to lay audiences.

Walt Disney on 16 mm.

Walt Disney Film Distributors Ltd, 68 Pall Mall, London, S.W.1, announce that three of their nature films—"Nature's Half Acre", "Seal Island", and "Beaver Valley"—are now available on 16 mm. for long lease to educational authorities and industry. Appraisal copies will be supplied to interested organisations. Readers may like to be reminded that "Nature's Half Acre" deals with the balance of species in nature, food chains, the relationships between animals and their young, and life history patterns, of many birds, plants, and insects. "Beaver Valley" shows the life of beavers and other animals in their natural habitat. "Seal Island" deals with the annual return of the fur-bearing seal to the Pribilof Islands in the Bering Sea, where they mate and bear their young.

Endoscopic Cinematography and Radioscopy

The Société Médicale Internationale de Photo-Cinématographie et Télévision Endoscopiques et de Radiocinématographie (Cine-Endoscopy and Cine-Radioscopy) was formally inaugurated with Prof. Soulas as president, at the seventh formal meeting of the Society held in Paris on December 8, 1956. The next meeting will be in Paris on March 9, 1957. Dr P. H. Holinger will act as president, and Prof. Chevalier L. Jackson as honorary secretary, at the first annual general meeting which will be held jointly with that of the American Medical Association in New York on June 3 and 4, 1957. The permanent honorary secretary is Dr J. M. Dubois de Montreynaud, 4 rue du General Baratier, Reims, Marne.

Time-Lapse Equipment

A small but efficient time-lapse unit for cinemicrography is being offered for sale for the first time in England. It embodies a standard 16 mm. Paillard-Bolex camera with a watching ocular, the camera being operated by means of a long cable release and an electro-magnetic plunger. The timer is a simple electronic device and gives intervals from one second to one minute. For normal work the only additional items required are a suitable support for the camera and a microscope. Such supports will be available later on.

Research workers who have wanted to use time-lapse cinemicrography have had in the past to design and construct their own equipment. With the increasing use of this technique, the new equipment should fill a long-felt need. The unit is available from SIMPL Ltd., 1–4 Lambeth High Street, London, S.E.1.

Animal Coloration

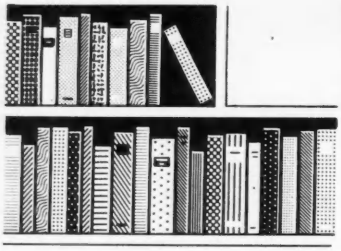
F. G. W. Knowles. 26-frame colour film strip, with notes. Common Ground (CGA 589 I.E.)

These photographs by Sir Francis Knowles, cover six main aspects of animal colour, for which the film strip is surely the ideal medium. The booklet gives an admirable short review of the subject, as well as descriptions of the frames and a reading list. The strip will be valued most for these notes and for the eight frames dealing with the author's special interest, colour change in prawns, showing changes in the pigment cells under hormone control. The rest of the strip has some successful illustrations. But it is too short for so broad a survey, and in some cases more familiar animals and better chosen angles or backgrounds would provide more effective examples. While this is an interesting introduction to the subject it is hoped that the publishers will follow it up with other strips dealing separately with concealing coloration, or with a full treatment of colour change.

F. C. MINNS

Anamorphic Projection

Anamorphic projection had been installed in more than half Great Britain's 5000 cinemas by last September, according to a recent Board of Trade statement. This is the type of projection that is better known as CinemaScope or VistaVision. The same statement says that since 1954 3-D has virtually dropped out. "Multi-channel sound apparatus" (such as Stereophonic and Perspecta sound) are now available in about 13% of all British cinemas.



THE BOOKSHELF

Sir Richard Gregory

By W. H. G. Armytage (*London, Macmillan and Co., 1957, 242+x pp., 21s.*)

There will surely be many to welcome the appearance of a connected and documented account of the life and the career of the late Sir Richard Gregory. Some of us had hoped that Gregory, whose book "Discovery, or the Spirit and Service of Science" was to provide a title for this Journal, as Professor Armytage notes in his biography, would be induced to write one himself; but he was always too busy with other interests, until age and ill-health made it no longer possible. We may be grateful, therefore, to Prof. Armytage for his care in reconstructing the truly remarkable story from Gregory's papers, and from memories which Lady Gregory and others have been able to supply. He certainly succeeds in evoking something of the fascination and the romantic quality of Gregory's early years. His father, an Alton Locke in real life, was a bitterly poor Bristol cobbler, but therewith a poet, a Methodist, and a pioneer socialist. Young Richard left school at twelve, to become a paper-boy, a page-boy, a pot-boy, and an apprentice in a shoe factory. The headmaster of Clifton College next encountered him, and offered him a job as an assistant in the school laboratory. Then, with a maintenance scholarship of one guinea a week, he went to the Normal School of Science at South Kensington, assisted C. V. Boys for a time, and made a number of lifelong friendships with fellow students, that with H. G. Wells being the closest of all. This friendship with Wells, with plentiful correspondence between them, enlivens the book at the cost of a certain lack of proportion; it meant much, indeed, to Gregory, but not all, surely, that its prominence in this story of his life would seem to suggest.

One has a similar sense of disproportion on seeing that more than half the chapters in the book, according to their titles, deal with the various organisations of a public and quasi-political character, with which Gregory became naturally associated as a champion of the interests of science. Gregory was easily attracted to such movements, and gave much time and effort to them; but they hardly deserve eleven out of twenty chapters in the story of his whole career, when there is not one chapter explicitly devoted to his editorial work for *Nature*, which most scientists, in all countries, would think of as his outstanding service to the cause of science. It should be added, however, that Prof. Armytage seems to find the right angle in his last chapter, entitled "Retrospect", where he recognises that Gregory's "real contribution to the 20th century was his management of *Nature*, and his use of it to deploy the forces of science in the cause of human advancement".

In spite, however, of any such apparent disproportions, the book not only recalls Gregory's many achievements, but also evokes the charm of his generous and ebullient personality, the readiness with which he was roused to enthusiasm or to indignation, and his warm and essentially simple humanity. It should be read by anybody who has, and indeed by everybody who ought to have, an interest in science, as an ever more predominant factor in our civilisation.

HENRY DALE

The Conquest of the Antarctic

By Norman Kemp (*London, Allan Wingate, 1956, 152 pp., 16s.*)

This book is a reasonably successful attempt to combine a concise account of modern Antarctic activity with a certain amount of historical background. Its objective is implied in the foreword by the Prime Minister of New Zealand, Mr Holland. New Zealand has accepted the responsibility for a largish section of Antarctica, and clearly, in a democracy, the stimulation of interest of a large number of the ordinary public is necessary for the provision by Government or Treasury of the financial resources required for the exploration and, later, the possible exploitation of the Ross Dependency, as this Antarctic territory has been named. A short account of early exploration, with particular reference to incidents and obscurities which have given rise to subsequent controversy about ownership, is followed by a graphic description of the work of Ernest Shackleton, one of the most notable British Antarctic leaders whose work lay both in East and West Antarctica.

Among modern work, that of Vivian Fuchs, who takes up the TransAntarctic torch where Shackleton laid it down, naturally takes pride of place. It is a spectacular venture with an element of adventure, even of gambling, which adds to the appeal. We are then given some account of the American application of technological know-how to Antarctic problems, with a hint at rival themes and cross-purposes among the responsible authorities. Massive resources applied with imagination have produced great dividends, but at a not negligible cost of lives. Consideration of the present American expedition leads naturally on to the New Zealand supplement to Dr Fuchs' TransAntarctic venture, which, under Sir Edmund Hillary, will be the main subject of New Zealand interest in the next two years. A reconnoitring party with the Americans last summer acquitted themselves with credit; and, as I write, the *Endeavour*, with Hillary's main party, prepares to cast off from the wharf at Lyttelton, hoping eventually to meet their colleagues from West Antarctica somewhere near the Pole. The book concludes with accounts of the British Royal Society expedition to the Weddell Sea; of Australian past and present work, with Sir Douglas Mawson as its chief protagonist and patron; of the Russians and the French, with, as an interlude, the most complete account I have yet read of the controversy between Great Britain, the Argentine, and Chile on the sovereignty of the Falkland Islands and the Grahamland complex. All this is set out in interesting fashion.

One can only regret that the author did not submit his manuscript for criticism to polar explorers themselves. It is marred here and there by mistakes that should not have been allowed to creep in. Observation Hill, topped by the Scott Memorial Cross, is 750 feet, not 12,000, feet high, and the tall, vicious Emperor penguins on the Kergulen island can only be a myth; though I can imagine that even King penguins might react quite violently to the treatment to which these birds were subjected in the interests of science.

RAYMOND PRIESTLEY

Animal Navigation

By J. D. Carthy (*London, G. Allen and Unwin, 1956, 151 pp., 18s.*)

How do migrating birds find their way? How does the carrier pigeon, when set free in an unknown district, turn and strike off in a homeward direction? How does the salmon succeed in returning from the broad ocean to the mountain stream of its youth? Such are the problems which have long intrigued biologists, but, in recent years, many observations and experiments have lifted the veil a little. A number of the phenomena of navigation by animals can be explained by the fact that their senses, such as smell or hearing, are sharper than our own or more effective in other ways. Thus bats can hear exceptionally well, and in this way can steer themselves during their nocturnal flight by means of a form of radar. The eyes of insects and other arthropods recognise the direction of vibration of polarised light and use this ability to a considerable extent in their navigation.

Dr Carthy's book provides a clear and comprehensible survey of the present state of research in this field and of discoveries during the past decade. We learn what an important part the sense of smell plays in many

ansAntarc-
r Edmund
subject of
next two
with the
itted them-
write, the
ain party,
wharf at
to meet
Antarctica
The book
he British
e Weddell
d present
son as its
n; of the
ith, as an
account I
versy be-
ntine, and
the Falk-
ahamland
n interest-

he author
script for
hemselves.
mistakes
llowed to
opped by
750 feet.
ll, vicious
Kergulen
ugh I can
ins might
atment to
ted in the

IESTLEY

G. Allen
18s.)
heir way?
when set
turn and
direction?
in return-
he moun-
h are the
intrigued
rs, many
ts have
er of the
animals
that their
ring, are
effective
can hear
way can
nocturnal
of radar.
r arthro-
vibration
is ability
eir navi-

a clear
of the
this field
the past
mportant
in many

cases, we hear about the navigational achievements of insects, about bird migration and its investigation, about fish migration, about lemmings and their senseless wandering to their death, about the long journeyings of seals, whales, bats, and so on. The story grips the reader, tells him of the latest discoveries, and attempts to explain them. At the same time it is clear how much remains a mystery even today.

K. V. FRISCH

The Physical World of the Greeks

By S. Sambursky (*London, Routledge and Kegan Paul, 1956, 255 pp., 25s.*)

Prof. Sambursky is director of the Research Council of Israel and a specialist in spectroscopy. He has written an absorbing book. The history of science is a young subject and there is debate as to how it should be written and who should write it. There would be no debate if all historians of the subject managed, like Prof. Sambursky, to combine distinction in pure and applied science with the necessary equipment in ancient and modern languages. For he not only bases himself on the original texts but succeeds in treating, in a way that should be acceptable to the professional scientist, that most treacherous and fascinating theme, the resemblance of Greek science to modern views and the nature of the difference between them. Though the book is a translation from the Hebrew, the style is excellent. In manner, too, it is attractive. Controversy is avoided. A select bibliography of contemporary or recent books suffices to indicate the literature on the subject, but, with a firm independence, the author confines himself to the exposition of his own views based on the 271 Greek passages catalogued in his List of Sources. Especially noteworthy is an original and convincing estimate of the scientific contribution of the Stoics. Most of us are familiar with the Epicurean exposition of the atomistic view of things. Few have any adequate understanding of the rival Stoic picture of the universe as a continuum. This is an able, original, and authoritative work.

One hesitates to join issue with the author of so good a book, but I find myself in disagreement with one of its themes. Prof. Sambursky persistently belittles the Greek achievement in technology and its bearing on their scientific development. Theophrastus, however, says (Athenaeus 511d) that their mature civilisation rested on a technological revolution which had taken place between the Heroic Age and his own time, which, as the result of inventions and improved techniques, had increased the amenities of life. Prof. Sambursky says the Greeks had no desire "to conquer nature". Aristotle in the opening sentences of his *Mechanics* makes precisely this claim for technology, and quotes the poet Antiphon in support. He might have quoted others, too. And in the opening of the *Metaphysics* he traces the growth of human knowledge and closely links technology with science, though here all the emphasis is on pure science. Cicero (*On the Nature of the Gods*, II, 60), following Stoic sources, claims that man, by his domination over nature, has created for himself a second nature within her realm. It is, perhaps, symptomatic of a bias on this point that Prof. Sambursky, who writes so much and so well about the philosopher Chrysippus, does not even mention the physicist Strato. All the same, I repeat, he has given us a splendid book.

B. FARRINGTON

The Geographer as a Scientist

By S. W. Wooldridge (*London, T. Nelson, 1956, 312 pp., with 30 diagrams and maps, 35s.*)

This volume includes sixteen essays written since 1931 by the leading exponent of geomorphology in Britain. All the essays illustrate the scope and nature of geography; but the first six essays deal philosophically with the rôle of geography, while the remaining essays reproduce ten of his chief memoirs dealing with the geomorphology of various areas in Britain.

The reviewer is probably better able to appreciate the aim of the book than almost any other geographer. He has been connected with six universities, and only at Chicago was there at first an established Department of Geography. It was usually his lot at the other five universities to try to convince the faculties that geography was a scientific subject. It is of course a liaison subject, and in the Toronto Department (in 1950) two-thirds of our courses were akin to science and only one-third might properly be referred to Arts.

Wooldridge's book very materially supports this thesis. He defines the aim of geography "to examine land-forms, soils, plants, as well as human phenomena in their natural contexts in area". For myself I have felt that the rather unpopular word "environment" expresses pretty clearly the last four words of his definition. If one discusses the relation of beetles and baboons to their environment it is legitimate science; if one does the same thing for that fairly important mammal "Man", it is geography and is denied a place in, for instance, the Royal Society.

Wooldridge first of all discusses the two classes of scientists, those who are interested in the broader issues shown in the field, and those who work mainly in the laboratory. He makes a special plea for geomorphology "because human patterns are so delicately related to surface relief that the geographer will never be able to divorce his study from geomorphology".

Man comes primarily into the world picture as an agent in differentiating the earth's surface. Geography has jocularly been defined as dealing rather with maps than with "chaps"; but it is with pleasure that I note that Wooldridge classes himself "with Griffith Taylor, and I hope others, a Geocrat", that is, a believer that the environment plays a leading part in determining how man differentiates his actions on earth.

Wooldridge's next essay develops the idea that geography is essentially an integrating discipline. Most of the other sciences are analytical . . . they take the clock to pieces, whereas the geographer has the harder job of trying to put the parts together again. He suggests that Applied Geography has been curbed in some official quarters because it may reveal matters too clearly. This has certainly been my own experience in the early days in dealing with arid and tropical problems in Australia.

Wooldridge opposes the scheme for combining geography with history in a Social Studies course. Many of us have found that this means that the historical side is fairly well treated, since teachers have for many a long year trained at universities in history. In Canada, for instance, until about 1940, few of them had any real knowledge of geography, and naturally imparted nothing of value to their unfortunate pupils. "By what right," says Wooldridge, "do we withhold knowledge of how our terrestrial home is constructed, the meaning of its scenery and of the patterns of its sky?"

He agrees, of course, that regional geography is the core of our discipline. If, however, it is divorced from systematic geography, as is the case in some institutions, there is danger, as our author puts it, that "regional geography may be little more than a regurgitation of factual gruel". He deprecates the attitude of some training colleges where the emphasis is so strongly on the methods of teaching that geography itself with its bearing on actual human problems is almost neglected. He deplores, as did so many of the older generation of geographers, the prejudice of the Royal Geographical Society in favour of exploration and cartography. Around 1920 the reviewer had his papers regularly refused in London, to be immediately accepted in America. Since that time no paper of mine has appeared in the famous London journal, though nowadays due space is given to other fields of geography than exploration.

In his sixth essay he points out what is not generally recognised, that geology is largely the "study of sea-bottoms, not of land-surfaces". This partly accounts for the lack of interest in geomorphology on the part of some geologists; they find little information about the landscapes of the past and so are not led to study the landscapes of today. It has been my misfortune that apart from a little field-work in the Grampians and around "Lake Lapworth" I have no first-hand knowledge of British geomorphology; hence I will close this review with the feeling that all geographers must study this book, which is in the class of Hartshorne's "Nature of Geography"; although it is

much easier to follow, and full of epigrams suitable for quotation!

GRIFFITH TAYLOR

Laboratory Administration

By E. S. Hiscocks (*London, Macmillan and Co. Ltd., 1956, 392 pp., 36s.*)

We are told on the jacket of this book that it is addressed to those who are concerned with the establishment or operation of scientific laboratories. The author is a research scientist-turned-administrator who draws widely from his experience in the Scientific Civil Service and quotes freely the practices at the National Physical Laboratory, of which he is the Secretary. He has tried to confine his subjects to matters of administration, mainly internal, which would be the concern of the laboratory manager rather than the research director.

An excellent chapter on "General Considerations" is followed by interesting discussions on the "Head of the Establishment" and "Functions of Staff". The next three chapters deal with staff matters from probationary employment to pensionable retirement. These chapters could well have discussed at greater length the problems posed in administering a community in which bright individualists on the one hand, and an average cross-section of workers on the other, are housed under the same roof. The long dissertation on Civil Service grades and rates may not interest many readers.

There is a useful treatise on "Flow of Information", dealing with reports, libraries, symposia, and open days, after which "Finance" and "Programming" are dealt with fairly briefly. The subsequent chapter on "Evaluation" actually deals with comparative costs, and here the author makes a plea for a code of practice which would permit better comparisons to be made of costs per man, space utilisation, and the ratio of scientific and technical and other staff.

"General Services" and "Technical Services" are discussed separately, and are followed by chapters on "Laboratory Buildings", "Patents", and "Training for Management".

The book is written somewhat as a collection of essays, and the presentation and clarity would be better if the text had been grouped under the subheadings given in the list of contents. The text is sparsely relieved by either plates or diagrams, though there are many diagrams, charts, and tables in the twenty-two appendices.

There are many interesting aspects of the growth of laboratories, discussion of which would have made the book much more useful to those concerned with young laboratories. Also, in view of the increasing number of industrial research and development establishments, it is a pity to find the author complaining of a paucity of information from such sources, but even so, many useful facts and figures are given which are applicable to any laboratory. This book cannot be compared with a volume such as "Research in Industry" published by Van Nostrand, with its formidable list of contributors, but Mr Hiscocks is to be congratulated on dealing single-handed with his subject within the terms of reference he has defined.

K. M. CAPLE

Burning Water

By Laurette Séjourné (*London and New York, Thames and Hudson, 1957, 192 pp., 22 plates, 82 figs., 25s.*)

This is a remarkable book by an archaeologist who has discovered a wonderful new field of Ancient Mexican mural paintings in the gigantic ruined city of Teotihuacan. It is not an account of the discovery but an interpretation of the religion which inspired the paintings. As such it demands a place on the bookshelves of the psychologist, the student of comparative religion, and the art lover, as well as the historian.

The book is written in a strangely vivid style which is intolerant of exact ordering of thought, and yet which presents an overall picture of a deep and passionate belief. The language is sober and clear enough, and the quotations from ancient Nahuatl poetry remind one of the remarkable Third Programme broadcast of last December by the translator of the book. This book tells of the theology which inspired the poetry. One finds the ancient Mexican priest seeking the universal goal of the mystic philosopher, the loss of self in the eternal flame of being.

There are weaknesses and errors enough, but the main theme is secure and throws much light on the attitude of the Mexicans towards pictorial symbolism. Unfortunately the author seems to have studied the frescoes and the written documents but only partially attempted to understand the material contained in the surviving pre-Columbian painted books. This has led her to misquote several references in her figures. Fig. 35 should be credited to Vaticanus 3773 not Nuttall; Figs. 64 and 65 come from Codex Rios and not Borbonicus. The interpretation of pictures from these codices is often curiously mistaken. A notable example of this is Fig. 36. Here the gods are creating Maize. They have placed the rich eared plant in the waters, and at the base of it they have two fine cobs of maize which are wrongly described as stone knives. The gestures of their hands which are described as movements of upward and downward directions are really the pointing of a forefinger to show that they are Lords who give command, and the spreading outwards of the fingers of the hands which hold penance-bones with which they pierce the *membrum virile*.

Archaeologically one should remember that the relationship between Teotihuacan and Tollan is not clear. It is not possible that Teotihuacan was the capital of the Toltecs at the time of the fall of their empire in the 10th century. Carbon dating has disposed of that possibility. But, accepting some of the Mexican legends, it becomes just possible that Teotihuacan was the capital of the Toltecs at the very beginning of their power in Mexico; but this is highly doubtful in view of the lack of Toltec-style calendrical glyphs at Teotihuacan and their contemporary existence in great numbers in the monuments of Santa Lucia Cotzumahualpa in Guatemala.

From the point of view of the study of religion our author is much too partial to the cult of Quetzalcoatl, but she expounds this very interesting belief with great thoroughness. One would say that she gave too little emphasis to Quetzalcoatl (whose name means Precious Twin, as well as Quetzal-feathered Serpent) as a planetary god, and too much to him as the first divinely appointed king of the Toltecs. But in this she is repeating the attitude of the native historians, who knew little of the whole system of twin gods which represented Venus as evening and morning stars among other American Indian tribes. The author is, however, careful to mention this aspect of Quetzalcoatl in passing.

The total effect of the book is of a partial but illuminating survey of ancient Mexican religion. It avoids no horror, but explains the inner philosophy which in later times was dramatised in circumstances of insane blood lust. That this philosophy was clear and rich must be the feeling of all who look at the Mexican images of the gods. Laurette Séjourné gives it life which for the first time reveals its true grandeur of conception. Because of this the errors one finds in interpretation of individual details are of less account than they might be.

The translation into English by Irene Nicholson has so true a ring that one is convinced that here is a work which not only gives a faithful rendering of the text but also a true picture of ancient Mexican ways of thought.

COTTIE A. BURLAND

Chemical Engineering Practice

Vols. I and II. Editors H. W. Cremer and Trefor Davies (*London, Butterworths Scientific Publications, 1956, 95s. per vol. In the U.S.A., Academic Press Inc., New York*)

"A continuing shortage of scientific manpower has become a familiar feature of the post-war scene. Its underlying cause is the accelerating pace of economic, political, and technical change in the modern world; and its most important manifestation the competition, both within and between industrialised countries, to apply the fruits of new scientific and engineering discovery to production and commerce."

The quotation above is from the opening paragraph of the survey of scientific and engineering manpower in Great Britain, which has just been produced jointly by the Ministry of Labour

and the Advisory Council on Scientific Policy. It is quoted here because the final clause defines better than anything else one of the main functions of a chemical engineer. It has long been the custom to assert that while the scientific effort of this country is second to none, in the U.S.A. the applications of science to the development of new processes is much more rapid and imaginative. One of the reasons put forward for this by an OEEC team some years ago was that in the U.S.A. there were available large numbers of men who had a broadly based training in the applications of science, and who were taught to consider an industrial problem in its economic context and in the context of human relations. These were the chemical engineers, and the post-war years have seen the rapid growth of this profession which has been acknowledged as a primary technology, and chemical engineering is now recognised as a suitable discipline for undergraduate and post-graduate studies at our universities.

The particular facility which the chemical engineer has—that of taking the fundamental chemistry and physics of a process and producing a design for production which must be correct in its scientific, economic, and human aspects—is difficult to teach. As may be expected, there is by no means general agreement on how it should be taught. There are those who claim that experience is everything, and the only way to build a plant is to "lift" the necessary information either from some existing plant or from a pilot plant specially constructed to try out the process. Others say that this results in the perpetuation of existing practices and the stifling of progress. Certainly the blind use of empirical methods has grave dangers, and the transfer of data can only be safely made on the basis of as complete a theoretical physical analysis as possible of the process being considered. The reconciliation of these two views might well have been in the minds of those responsible for the new series of books entitled *Chemical Engineering Practice*, which is being produced in about twelve volumes under the general editorship of H. W. Cremer. Mr Cremer, in his preface, states that these books will be much more than handbooks of existing empirical methods. "Those who have been responsible for the form of the present publication", he writes, "were very sensible of the fact that under the stress and speed of modern industrial developments the chemical engineer is increasingly at a loss to find ready-made answers to his problems. There still remains a great gulf fixed between theory and practice, a space which of necessity he must, on occasion, endeavour to fill. Consequently, it was thought appropriate to include what some may regard as a disproportionate amount of *theory* in a treatise in the title of which they are likely to regard *practice* as the objective word."

The fact that chemical engineers have the entrée to any of the twenty-odd process industries is indicative of the immense field which a comprehensive work is expected to cover, and the services have been secured of leading chemical engineers in the United Kingdom and the Continent, both from the universities and from industry. To have done this is itself a considerable achievement on the part of the editor. The level of scholarship expected of the readers is also made clear; the assumption is made that they have attained a first-degree standard in the pure or applied physical sciences, and have adequate mathematical knowledge.

Of the two volumes which have just appeared, the first is concerned mainly with three familiar aspects of the chemical engineer's work; material and energy balances on reacting systems, the design and operation of pilot plants and the interpretation of results obtained from them, and the preparation of flow diagrams for full-scale production processes. There are preliminary chapters on the scope and philosophy of chemical engineering and in the economics of production, and a chapter on units and dimensions which seems somewhat misplaced at the end of the book. In Vol. II, the first half is devoted to the structure of solids, and has chapters on metals and metallic alloys, fatigue, and creep in metals and the mechanical properties of plastics. The second half of the volume discusses corrosion and then various aspects of porous structures, including powder metallurgy, but the most important part consists of considerations of fluid flow through porous masses, with reference to combustion in solid fuel beds to the purification of coal-gas, and to the treatment of water and sewage. There is a final chapter on transpiration cooling, which is an important principle being applied in the design of rocket combustion-chambers and some gas-turbine blades.

It is difficult to classify the utility of these books. Much of the subject matter, as for example the material and energy-balance section of Vol. I, is of direct value for undergraduate teaching. Other sections, for example the purification of coal-gas, describes modern industrial practice. The chapter on transpiration cooling would serve as an introduction to the subject suitable for a research student about to start work in that field. All this is indicative that the work as a whole is a most ambitious undertaking, but the editors can congratulate themselves that they have made a good start.

E. S. SELLERS

The Determination of Toxic Substances in Air (A manual of ICI Practice)

Edited by N. Strafford, C. R. N. Strouts, W. V. Stubbings (*Cambridge, W. Heffer and Sons Ltd., 1956, 35s.*)

In the preface of this book the hope is expressed that it will usefully supplement the various methods for the determination of toxic gases in the atmosphere which had been published by DSIR. This it undoubtedly does. The manual, compiled under the direction of the Analytical Chemists Committee of ICI, is an excellent collection of accurate methods for the determination of concentrations of toxic substances in air and should be of great value in chemical works or to anyone interested in making precise checks on the condition of the atmosphere. Whereas the DSIR leaflets, covering rapid and simple methods with a limited accuracy are intended to serve the man with a small chemical skill and modest equipment, the use of this manual of precise methods requires skilled analysts and a properly equipped analytical laboratory. Of the methods described, covering forty-nine different toxic substances or groups of substances, twelve have been officially adopted by the International Union of Pure and Applied Chemistry, while a further five have been provisionally accepted. Each method is well set out and clearly described with full details as to scope and the apparatus and reagents required, diagrams being included wherever necessary.

The authors are obviously fully acquainted with the difficulties of securing truly representative samples of contaminated atmospheres and have provided standard methods of sampling for use with these tests. There is a comprehensive index, and a table of toxic concentrations is included; a helpful feature is the indication for each test of the time required for its performance. As might have been expected in a publication sponsored by an organisation which is acutely safety-conscious, precautions for safeguarding the operator are recommended whereever necessary, a feature which is lamentably lacking in many treatises on chemical analysis.

D. A. YONGE

Brief Notes

The December issue of the Scientific Film Review, 164 Shaftesbury Avenue, London, W.C.2, contains details of eighty films on various aspects of automation. Copies are 3*s*. 9*d*. each.

The French *Centre National de la Recherche Scientifique* has brought out a booklet priced at 300 francs on the "Centre de Documentation Cartographique et Géographique" in Paris.

In this age of plastics it is refreshing to turn to a booklet called "The Faithful Fibre", published by the Linen Thread Company, 95 Bothwell Street, Glasgow, C.2, describing how linen has been used from the days of the Bayeux Tapestry to this airborne age when it is used to stitch parachute harness.

The Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1, has issued an illustrated booklet, "Chemical Engineering, a Career", designed for senior pupils seriously considering what they will do when they leave school.

LETTERS TO THE EDITOR

Space Travel and Ageing

Sir:

Professor Fisher's approach to the controversy between Dingle and McCrea seems to me to raise a new problem rather than settle an old one. It is unnecessary to consider accelerated motion in order to settle the argument.

Consider the following experiment conducted with three space-ships, A, B, and C, in a frame of reference in which A is motionless. In this frame of reference, B is supposed to be moving from left to right of A, parallel to the trajectory of C, which is moving from right to left of A. These trajectories both graze A, so that the separation at closest approach of A and B, B and C, and C and A can be regarded as infinitesimal.

Let it be supposed first that B passes A, and at a somewhat later period encounters C, which will later still pass A going in the opposite direction. Let it be supposed that all three are in communication with one another by radio and carry clocks of the ammonia or caesium variety designed to be independent of the secondary properties of matter. At the moment of closest approach, A and B set their clocks at zero. Later, C sets his clock to the reading on B's as they pass, and at the conclusion of the experiment, on passing A, C compares his clock reading with A's. Does it agree? The answer on Dingle's interpretation of the theory is that it does. It will be observed that no accelerated motion is involved in the conditions of this imaginary experiment, which depends solely on the postulates involved in the special theory of relativity. These are concerned with defining the space-time co-ordinates of points at a distance in terms of such information as can be transmitted and received between them.

Dingle's solution of the above problem has already been published in the *Proceedings of the Physical Society*,* and it will be interesting for those who have been following the controversy to learn, in due course, whether McCrea accepts it or not.

If he accepts Dingle's solution, then he will be committed to the view that clock retardation is not a physical effect intrinsic in the idea of "there and back" within the scheme of special relativity theory, but that, if physically real, it must be due to an "acceleration effect", not a "velocity effect".

If he does not accept Dingle's solution, then clock retardation, if physically real, will be explicable in his view as a "velocity effect" and it will be unnecessary to complicate the discussion by reference to accelerations.

I write "if physically real" because the experiment or its equivalent has not been carried out and, like any experiment, could in principle lead to a result in unexpected conflict with theory. My concern is only to define the possible point of conflict in terms of the theoretical implications.

HALSBURY.

National Research Development Corporation, London, W.1

* *Proc. phys. Soc.*, 1956, vol. 69A, p. 925. *Bull. Inst. Phys.*, 1956, December, p. 314.

Sir:

The correspondence between Sir Ronald Fisher and Prof. McCrea on the clock paradox, which you published in DISCOVERY of February, though interesting, is really quite beside the point. The whole matter could be settled at once if someone would indicate the flaw in the following argument:

(1) According to relativity, if two bodies (e.g., two identical clocks) separate and reunite, there is no observable phenomenon that will enable one to say, in an absolute sense, that one rather than the other has moved.

(2) If, on reunion, one clock is retarded by a quantity depending on the motion and the other is not, that phenomenon would enable one to say absolutely that the first had moved and not the second.

(3) Hence, if relativity is true, the clocks must be retarded equally or not at all: in either case their readings will agree on reunion if they agreed at separation.

I have vainly appealed to many eminent persons who have written me on this subject, to tell me what is wrong with this argument, but have not succeeding in eliciting even one distant comment on it; it is avoided like a plague.

May I now ask Sir Ronald Fisher or, once more, Prof. McCrea, or anyone at all, to tell me which step (1), (2), or (3) in the argument is wrong, and why? It should be so simple, and the result would be conclusive. I would be content with what I already know about inertial systems, geodesics and non-geodesics, and the like, if only I could be enlightened on this single point. Will no one come to my assistance?

HERBERT DINGLE.

Purley, Surrey.

Sir:

Unless I misunderstand the paradox discussed, the problem is an artificial one which arises from ascribing to local observations a measure of absolute validity which they do not possess, and may perhaps be cleared up by a simplified illustration.

Let it be assumed for convenience—since figures have no bearing on the principle—that light has a speed of ten metres per second. Two observers, A and B, are each equipped with a clock which emits a light pulse ten times per second. These pulses, as they travel outward, will thus have a spatial separation or wavelength of one metre.

Let A and B be considered first as close together with their clocks synchronised. They then move apart at a uniform velocity of five metres per second. This is a relative velocity and it is immaterial whether we regard it as shared between A and B in any particular way.

A records time on his own clock and counts the pulses he receives from B's. At the end of a second he has counted ten of his own pulses, but has only received five from B, and he therefore concludes that the latter's clock is running slow. However, at this time A and B are five metres apart and five of B's pulses are therefore still in transit. B's observations of A are, of course, exactly similar, and for the same reason.

As A and B continue to move apart they will continue to observe the apparent slowness of one another's clocks, but if their relative movement ends, neither will find any discrepancy in the rate of the two clocks but each will believe the other's to have lost by a number of pulses equal to the number of wavelengths by which they are separated, since the missing pulses are still in transit between them.

If they approach one another again, A and B will each observe that the other's clock is going fast, and when they come together once more the two clocks will be in synchronism again and A and B will be in agreement as to the total number of pulses given by their own and one another's clocks.

If it is felt that, owing to the peculiarities of the inertial fields to which one or the other has been subjected, a *permanent* difference may be induced between the clocks of A and B, the matter may be resolved by postulating a third observer, C. C is to be supposed to move in such a way that his motion relative to A is at all times equal to his motion relative to B. This being so, C will at no time observe any discrepancy between A's and B's clocks, and these, when they come together again, must therefore agree.

BENNETT WESTON.

London, W.12

Sir:

I hope I shall not be thought flippant if I ask, with regard to Sir Ronald Fisher's "more realistic" suggestion, whether, towards the end of five years, for one passenger, without allowance for luggage or machinery, the power demand of the wonderful kinematic engine would lie between 10^{9} and 10^{10} h.p.?

E. HOGBEN.

Beckenham, Kent.

Sir Ronald Fisher replies:

Sir:

Miss Hogben is quite right. The trip was very expensive. Fuel consumption necessarily exceeded 10^{10} metric tons. But the baby was never neglected, and no cheaper time machine was available.

R. A. FISHER

Professor W. H. McCrea replies:

Sir:

In Lord Halsbury's problem, let the frame in which A is motionless be an inertial frame and let B, C have velocities $\pm V$ relative to A; let c be the speed of light. Let clocks A, B read zero when they pass each other. When A, C pass each other, if clock A reads T, then clock C reads $T\sqrt{(1-V^2/c^2)}$. This, noting Lord Halsbury's careful statement, is the correct *theoretical* deduction from special relativity. The problem has been discussed many times (H. Arzeliès, *La cinématique relativiste* (Paris, 1955), pp. 141–150; see particularly the historical notes and bibliography); the most illuminating discussion is that of H. E. Ives (*Nature*, 1951, vol. 168, p. 246); Dingle ignores the solutions already given and his own treatment is vitiated by various errors.

In Prof. Dingle's letter, his statement (1) is demonstrably false. Let one observer R remain at rest in an inertial frame and let a second observer M leave R and later rejoin R. When they are not together, let each put his hand out of the window and release a test-particle. After they rejoin, R's particle will still be beside him and M's particle will be miles away. This is an "observable phenomenon" that indicates an absolute difference between R, M. There are innumerable other such phenomena: M will see changes in the Doppler displacements of stellar spectra and R will not; if R makes any set of observations of M and if M makes corresponding observations of R, the two sets of results will be different; and so on. Of course, it is not necessary to say that "one rather than the other has moved". All that matters is that there is an absolute difference between their behaviours and that this is readily ascertainable by observable phenomena, including the comparison of the clocks on separation and reunion.

It is also obvious that Dingle's "argument" is not an argument. His statement (1) denies that there is any observable phenomenon that will reveal an absolute distinction between the motions of the two bodies. So, in particular, it denies that there is a difference between the observed durations of the journeys. Thus Dingle merely asserts the result he professes to establish, and his assertion is manifestly false.

Mr Weston's letter also begs the question. All that can be inferred from his treatment is the obvious conclusion that A, B, C all agree as to the number of pulses given by any one particular clock between any two particular events in its history. The question as to whether two *different* clocks give the same or different numbers of pulses cannot be settled in this way.

The fundamental point is that it is not meaningful to speak merely of the motion of one body relative to another with no reference to the rest of the universe. There are absolute differences between walking along, say, a corridor in the *Queen Mary* when she is in harbour and when she is in an Atlantic storm, even though one might claim that one's motion relative to the ship is the same on both occasions. In special relativity, as in classical mechanics, reference to the rest of the universe is made by using the concept of inertial frames of reference. Neither theory can say anything about the behaviour of a physical system unless the relation to an inertial frame is specified. If two clocks move in such a way that there is no inertial frame in regard to which their motions are symmetrical, there is therefore nothing surprising, and certainly nothing inconsistent, if relativity theory shows that their behaviours are, in general, not the same.

W. H. McCREA.

Royal Holloway College.

TWENTY-FIVE YEARS AGO

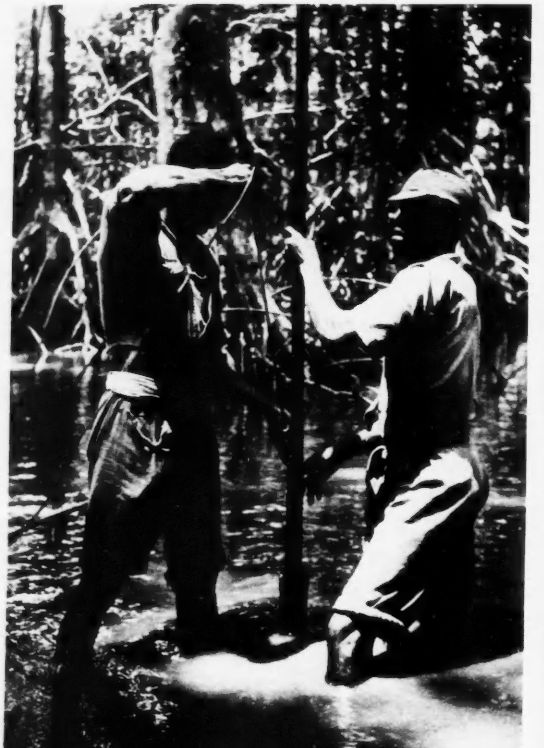
THE NEUTRON AND THE WILSON CLOUD CHAMBER

The first item in "Notes of the Month" for DISCOVERY of April 1932 announces "a discovery of far-reaching importance" by Dr J. Chadwick. "Working at the Cavendish Laboratory, Cambridge, he has obtained evidence of a new kind of ultimate particle called the 'neutron'. About ten years ago its possible existence was suggested by Lord Rutherford to explain the various problems as to the nature of matter, but only now has the neutron been confirmed as a definite factor in physics. The observation of particles and radiations has been undertaken for many years at Cambridge under Lord Rutherford's guidance, and it was in the course of this highly specialised work that the new discovery was made. Commenting on the neutron—'a massive particle with a positive charge of electricity in *intimate* contact with the mass-less unit of negative electricity, the electron'—Dr A. S. Russell foresees an interesting future for it, as soon as it is firmly established in the body of atomic physics. 'Mathematicians will begin with renewed energy to determine its place in the structure of the nucleus. Experimenters will examine its relation to the cosmic radiation. . . . Those who work in radioactivity will determine whether or not, in common with alpha- and beta-particles, it is expelled during the disintegration of atoms. . . . A particle which combines mass with enormous penetrating power is something of a wonder.' (*Listener*, March 9th.) . . . Meanwhile, on another page the photography of high-speed protons is described by some American physicists, who claim to have obtained these remarkable photographs for the first time."

The photographs referred to were from the Carnegie Institute and are of the "Wilson cloud chamber". The article accompanying them says: "Early in 1931 high-speed protons or hydrogen nuclei, similar to the high-speed helium nuclei or alpha-particles which are the third type of ray emitted by radium, were produced and measured in the laboratory at Washington. The energies of the artificial rays so far produced, however, do not yet equal the fastest of those emitted by radium. To accomplish this will not involve inherently new problems, as far as can be foreseen, but only an extension of the present equipment to dimensions suitable for still higher voltages. . . .

". . . The cloud-chamber used in photographing the trails made by the protons is an ingenious piece of apparatus devised in 1912 by Prof. C. T. R. Wilson, a distinguished English physicist. It was suggested by a series of earlier experiments by which it was shown that dust particles in the air are essential to the forming of clouds, it being difficult to make water vapour condense without the presence of such centres about which the droplets may form. Wilson found that ionised molecules of air (air electrically charged) would serve quite as well as dust particles. Indeed, it is such ionised molecules in the upper air which gather the moisture about them and form our clouds. Wilson thereupon devised a chamber so arranged that he could shoot alpha-particles into its moisture-laden dust-free air, at one and the same time ionising the air and producing droplets of condensed water vapour which reflect light when it is thrown upon them."

Twenty-five years ago the trails of aircraft flying at very great heights were an unknown sight, and an explanation of the principles of Wilson's cloud chamber were far more essential than it would be today.




New discoveries of oil are made daily, but a great deal of seismographical exploration must go on before new sources can be located. The photograph on the left shows the drilling of an exploration well, while on the right an appraisal well is being sunk to determine whether oil exists in economic quantities.

FAR AND NEAR

"Atom-smasher" for Canadian Nuclear Research

A new type Van de Graff particle accelerator will be installed, early in 1958, at the Chalk River facility of Atomic Energy of Canada Ltd. The machine, designed and manufactured by High Voltage Engineering Corp., Burlington, Mass., will enable physicists to study in continuous detail for the first time the nuclear energy level of heavy elements which they know only in patches today.

The 10-million-volt unit, called a tandem accelerator, consists of two 5-million-volt accelerators placed end to end, with a common high voltage terminal. The 35-ton accelerator, 34 feet long and 8 feet in diameter, is to be mounted on a rail in an L-shaped building 150 feet long and 60 feet wide. A separate building houses controls and services. The machine is to be equipped with a switching magnet that makes it possible to shift the intense beam of particles into any one of four directions, depending on the type of study under way.

Fast and Fertile

Ciba's *Medical News*, published in New York on January 14, contains the following alarming item: Mankind should be alert to "a peculiarly fertile species which reproduces freely and appears to have no natural enemies to hold its growth in check". The alarm was sounded by Dr Glenn Seaborg, University of California, Berkeley, speaking at the AAAS meetings.

He noted: "This species has the peculiar feature that the offspring is always 6 inches longer, 3 inches wider, 10% more powerful and 20% shinier than its parent. . . . It will be interesting indeed to note the breeding habits of the auto 50 years hence."

Fluon

ICI recently staged a small exhibition at its headquarters in London to bring their new plastic, Fluon, to the notice of a wider public. Fluon is interesting from a number of points of view. It is an inert, non-toxic thermoplastic made from the basic raw materials fluorspar and chloroform, having the chemical formula of polytetrafluorethylene $(C_2F_4)_n$. It resembles in appearance and chemical structure polythene $(C_2H_4)_n$. It is ivory white, smooth, and waxy to the touch. It is extraordinarily resistent to chemical attack, and no known solvent exists: it is only effected by molten alkali metals and fluorine. Its dielectric properties are better than those of polythene, and it is also a good electrical insulator. Perhaps most important is its extremely low coefficient of friction and its non-stick surface; few materials will adhere to it. It is perhaps not surprising, therefore, that this interesting plastic has already found a fair number of industrial uses where its peculiar properties are valuable. At present its price is still very high, of the order of £2 or £3 per lb.

an be
nk to

he notice
nteresting
iew. It is
stic made
fluorspar
chemical
rethylene
ance and
$C_2H_4)_n$. It
xy to the
sistent to
n solvent
molten
dielectric
of poly-
electrical
tant is its
ction and
rials will
surpris-
teresting
number
peculiar
esent its
order of

The Old Do Not Slow Down

The American Chemical Society weekly, *Chemical and Engineering News*, reports more and more chemical companies now recognise that their over-forty scientists may still be highly productive. Many concerns, in fact, have set up "senior scientist" programmes to let researchers of proven ability continue their laboratory careers instead of turning to administrative work. "Some years ago", the report points out, "the theory was rampant that, after the age of about 35 or 40, the average researcher began losing his creative spark. The chance of his making a major discovery was believed to drop off sharply. Hence, there really wasn't much point in encouraging a man of 45 or 50 to do research."

Recent experience has shown management, the report says, that age itself is no criterion for judging an individual's capacity for research, that "a man with a good scientific mind who advances in years does not necessarily become a poor researcher, or, for that matter, a good administrator".

The scientist-turned-administrator may not be altogether lost to science, the report notes. On the contrary, he can be most helpful in seeing that the contributions of researchers are wisely used.

The fact remains, however, that many scientists have no interest or talent in administration. The paper work, policy-making, constant concern with budgets, personnel problems, and other details of an executive's day are distasteful to them. Their preference is definitely for the creative challenge of research.

Such are the men for whom the senior scientist programmes are meant. In essence, the programmes "enable the researcher to advance by climbing a ladder within his own field".

"In former years", the report explains, "a laboratory had only one ladder—administration. Now a scientific ladder has been created, one that in many companies exactly parallels the route of administrative advancement. In establishing a two-way path towards the top, companies have vastly improved the status of qualified researchers."

Some companies have had senior scientist programmes for a decade or more. Many, however, have adopted them only within the past two or three years. Different titles are used to distinguish various levels of laboratory advancement. Typically, advancement from "research chemist" to "scientist" to "senior scientist" is used to parallel the administrative advancement from group leader to assistant or associate director to director.

Semi-Microchemistry

Norwood Technical College will hold a course of twelve lectures on semi-micro-chemical methods, with appropriate practical work designed to survey the principal branches of chemistry in which small-scale methods have been successfully applied. The course will be held on Saturday mornings from 9.15 a.m. to 12.30 p.m. at the College, Knight's Hill, London, S.E.27. This course is particularly suitable for teachers, industrial and research chemists. It begins on April 6.

The following topics will be surveyed: scope, aims, and achievements of small-scale techniques; design and construction of simple apparatus; organic and inorganic preparations on a reduced scale; simple chemical microscopy and photomicrography; inorganic qualitative and volumetric analysis; organic qualitative and quantitative analysis; micro-techniques for the determination of molecular weights, etc.

Application forms may be obtained from the Secretary of the College. The fee for London residents is £1.

Conference on Radio-isotopes

An international conference on the use of radio-isotopes in research will be convened by the United Nations Educational, Scientific and Cultural Organisation next September, in Paris. The conference will work in two main sections, one dealing with radio-isotopes in the physical sciences, and the second with the biological sciences. The first section will cover such fields as geology and geophysics (including meteorology and oceanography) and metallurgical and industrial research. The second will take up the use of radio-isotopes in biochemistry (including plant biochemistry and photosynthesis), human and animal physiological research, nutrition research, basic medical research, and certain branches of agricultural research, including soil fertility, plant and animal pathology, and the use of insecticides.

Supersonic Airliner

The British Aircraft Industry is to design and produce a supersonic airliner on a co-operative basis. Details are not at present being disclosed, but the following seven companies are concerned: Avro, the Bristol Aeroplane Company, de Havilland, Handley Page, Rolls-Royce, Short and Harland, and Vickers-Armstrongs.

A project of this nature will probably take at least ten years to produce, since a considerable number of problems will have to be overcome. The difficulties inherent in the design and successful operation of a supersonic passenger-carrying airliner are great. Much depends on just how supersonic the first aircraft of this type is to be. If a speed of Mach 1·8 (some 1100 m.p.h. at above 36,000 ft., or 1770 km.p.h. at above 10,972 m.) is planned, special metals, such as titanium or even stainless steel, might have to be used to resist the heat (about 85°C at that speed and height) caused by air friction. On the other hand, an airliner designed for a speed of Mach 1·2 or less (about 800 m.p.h. or 1280 km.p.h.) would not suffer from this disability. The wings themselves need not be designed for supersonic flight, either. This apparently inexplicable fact is explained by the utilisation of acute sweepback. The airflow parallel with the fuselage over the wings would be supersonic, but at an angle of 90° to the leading edge (and this is what counts aerodynamically) the air would be achieving perhaps Mach 0·98. The advantages of subsonic wings would therefore be reflected in range, economy, and handling.

On the other hand, a wing designed for supersonic flight must be thin and knife-edged, and quite a different configuration is demanded for take-off, landing, and subsonic flight generally. This is because air, when compressed, behaves rather like a crowd of people through which a car is attempting to pass. If it goes slowly, the people have time to get out of the way; but if it charges them, people do not have time to move. It meets a solid mass, and great power is needed to make further progress.

Thus, air molecules can get out of the way of a moving body providing it is advancing slower than the speed at which the pressure disturbance can "warn" the molecules ahead. At the speed of sound, this warning does not have time to operate, and "compressibility" makes extra demands on engine power and, consequently, fuel consumption.

Australian Process Aids Atomic Power

Overseas rights to CSIRO's process for producing pure zirconium, a vital metal in certain types of atomic reactors, has been sold to an American company, National Distillers Products Corporation, for $250,000. The process was developed by Mr Ivan Newnham, an officer of the CSIRO Division of Industrial Chemistry. Mr Newnham has been working with the company in America for several months, and as a result the process is now at the pilot plant stage in the company's Cincinnati research laboratories. The process reduces the cost of separating hafnium from zirconium by eliminating the cumbersome extraction step in current and projected commercial production. It will be far less expensive than other methods, which rely on a series of chemical steps to remove the unwanted element.

National Distillers have a contract to supply the U.S. Government with 5,000,000 pounds weight of reactor grade zirconium over a five-year period. It expects to sell the metal for about $7 per pound. When the new process is operating there will be a reduction in price.

Atomic Icebreaker

Details of the design of the atomic icebreaker to be built in the U.S.S.R. have now been drawn up. Its overall length will be nearly 440 ft., width nearly 91 ft., displacement 16,000 tons, speed in ice-free water 18 knots, capacity of main engine 44,000 h.p.

The ship, whose controls will be completely automatic, will be able to cruise for a year or more without putting into port.

Classified Advertisements

OFFICIAL APPOINTMENTS

EXPERIMENTAL OFFICERS/ASSISTANT EXPERIMENTAL OFFICERS
required by
THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT,
ALDERMASTON, BERKSHIRE

(*a*) To be members of a team studying nuclear interactions of fast neutrons. The work involves development of neutron spectrometers utilising millimicrosecond time of flight techniques in conjunction with Van de Graaf and Cockcroft Walton accelerators. Experience with scintillation counters or fast electronic techniques an advantage.

(*b*) To be concerned with experimental equipment for precise study of energy levels in light nuclei; to analyse experimental data obtained with 6 Mev Van de Graaf generator. Familiarity with scintillation counting techniques an advantage.

(*c*) A.E.O. to assist in nuclear disintegration experiments with 3 Mev Van de Graaf generator and in developing apparatus for these experiments.

(*d*) A.E.O. to assist Scientific Officers in carrying out original research into problems arising in the application of electronics to nuclear physics.

For posts (*a*) to (*d*), G.C.E. in 5 subjects with English Language (Ord.) physics and maths. (Adv.) or equivalent required.

(*e*) E.O. and A.E.O. to assist section responsible for programme of fast neutron irradiation experiments associated with high voltage accelerators using wide range of nuclear radiation counting equipment. Scope for development of new techniques for increasing precision of fast neutron cross-section measurements. Pass degree (physics) or H.N.C. required and some experience with radioactive materials or nuclear radiation detection equipment essential for the E.O. post. Applicants for the A.E.O. post should possess qualifications as (*a*) to (*d*) above and basic knowledge of nuclear radiations and nuclear radiation detection an advantage.

(*f*) To assist in development of methods of obtaining pulsed outputs from high energy electrostatic generators. Qualifications as (*a*) to (*d*) above or H.N.C. Previous experience with R.F. or ion source techniques desirable.

N.B. Candidates applying for E.O. posts should be at least 26 years of age.

Salary: Experimental Officer
£940–£1155 p.a.
Asst. Experimental Officer
£375 (age 18)–£665 (age 26 or over)–£815 p.a.

At present the rates for women are slightly lower.

Contributory Superannuation Scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to Senior Recruitment Officer at above address.

Please quote ref. 1445/47.

ASSISTANTS (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts.

Age at least 17½ and under 26 years of age on January 1, 1957, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:

(*i*) Engineering and physical sciences.
(*ii*) Chemistry, bio-chemistry and metallurgy.
(*iii*) Biological Sciences.
(*iv*) General (including geology, meteorology, general work ranging over two or more groups (*i*) to (*iii*) and highly skilled work in laboratory crafts such as glass-blowing).

Starting-pay £340 (at 18) up to £460 (women £431) at 25. Men's scale maximum £635. Women's scale being raised to reach equality with men's by 1961. Somewhat less in provinces. Opportunities for promotion and for further education. Five-day week, generally.

Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S59/57.

Interview Boards sit at intervals, as required. Early application is advised.

APPLICATIONS are invited for pensionable posts as

EXAMINERS
in the
PATENT OFFICE

to undertake the official scientific, technical, and legal work in connexion with Patent applications.

Age at least 21 and under 35 years on January 1, 1957, with extension for regular Forces' service.

Candidates must have (or obtain in 1957) 1st or 2nd Class Honours in Physics, Organic or Inorganic Chemistry, Mechanical or Electrical Engineering or in Mathematics, or an equivalent qualification, or have achieved a professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. For a limited number of vacancies candidates with 1st or 2nd Class Honours degrees in other subjects—scientific or otherwise—will be considered. Exceptionally candidates otherwise qualified by high professional attainments will be considered.

Starting pay for five-day week of 42 hours in London between £605 and £1120 (men) according to post-graduate (or equivalent) experience and National Service. Maximum of scale £1345. Women's pay above £605 slightly lower but is being raised to reach equality with men's in 1961. Good prospects of promotion to Senior Examiner rising to £2000 (under review) and reasonable expectation of further promotion to Principal Examiner.

Application form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S 128/57 and stating date of birth.

Interview Boards will sit at intervals, as required. Early application is advised.

APPOINTMENTS VACANT

THE
RESEARCH LABORATORIES
OF THE
GENERAL ELECTRIC
CO. LTD.,
NORTH WEMBLEY,
MIDDLESEX,

invite applications from PHYSICISTS, to work on Discharge Lamp Development, Crystal Analysis, and in Solid Physics.

ELECTRICAL ENGINEERS and PHYSICISTS are also required for work on Semiconductor Development, Transistor Applications, and Industrial Heating.

There are also vacancies for CHEMISTS and METALLURGISTS.

Successful candidates will have opportunities of advancement to positions carrying high remuneration.

An applicant should preferably hold a good honours degree, but men with pass degrees or higher national certificates will be eligible for some of these posts.

Apply, in writing, to the Staff Manager (Ref. RLO/120), giving particulars of experience, qualifications, and age.

MULLARD EQUIPMENT LTD, 51–55 Garratt Lane, Wandsworth, S.W.18, require "TECHNICAL AUTHOR", for work in the preparation of user-handbooks in the industrial electronic and telecommunications fields. A thorough technical knowledge of electronics is essential, and a degree or H.N.C. in electrical engineering is desirable. Previous experience in technical writing is not necessary. Apply: Personnel Officer.

NORTH LINDSEY TECHNICAL COLLEGE

Kingsway, Scunthorpe, Lincs.

Principal: F. C. Jones, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E.

Department of Science & Metallurgy

Applications are invited for the following appointments to commence duties September 1, 1957:

(1) Lecturer in Metallurgy for National Certificate and other courses. Ability to specialise in one of the following: Metallurgical Analysis, Fuels, or Physical Chemistry to H.N.C. and L.I.M. standard will be a recommendation.

(2) Assistant Lecturer Grade B to teach mainly Chemistry to Ordinary National Certificate and Organic Chemistry to Higher National Certificate classes. Ability to assist with either S.1 Physics or S.1 Mathematics will be additional recommendations.

Candidates should hold university degrees or equivalent qualifications. Both posts offer considerable opportunities in a Department transferring next September to new buildings with modern laboratories and equipment. Facilities for research are available.

Salaries are in accordance with the Burnham Scale for Teachers in Technical Colleges, i.e.

Lecturer	£1200–£1350 p.a.
Assistant Grade B	£650–£1025

with usual allowances for qualifications and experience.

Forms of application and further particulars can be obtained from the Principal at the above address to whom completed applications should be returned by April 13, 1957.

EDITORIAL SECRETARY, female, 22/30 years, required by "Vacuum" (Scientific Publications), minimum educational standard, Higher School Certificate; experience as editorial secretary in publishing concerns (books and/or journals) essential; good shorthand speed required and ability to work on own initiative; permanent and pensionable post. Commencing salary, £500 per annum. Housing available if from London area. Write, giving full details, to Personnel Manager, Edwards High Vacuum Limited, Manor Royal, Crawley, Sussex.

LECTURES AND COURSES

CHELSEA POLYTECHNIC

(College of Advanced Technology),

Manresa Road, S.W.3

(Telephone: FLAxman 5747)

FULL-TIME and part-time day and evening Courses are arranged in BIOLOGY, BOTANY, CHEMISTRY, GEOLOGY, MATHEMATICS, PHYSICS, PHYSIOLOGY, ZOOLOGY, in preparation for the B.Sc. (General) degree of the University of London for internal and external students, and for professional examinations.

Courses are also held for the B.Sc. internal special or honours degrees in BOTANY, CHEMISTRY (full-time only), GEOLOGY, MATHEMATICS, PHARMACY, PHYSICS, PHYSIOLOGY (evening only), and ZOOLOGY.

Facilities are available for research and post-graduate study and short courses of lectures are held on special topics. In PHARMACY, a full-time course is arranged for the Pharmaceutical Chemist qualification of the Pharmaceutical Society. Sandwich Courses (approved or in active preparation), leading to Diploma of Technology and suitable for works-based or College-based students, are available in APPLIED BIOCHEMISTRY, APPLICABLE MATHEMATICS, PHARMACEUTICAL TECHNOLOGY, APPLIED PHARMACOLOGY, and APPLIED PHYSICS. State Scholarships may be held at the College for these courses. Special evening courses in Biochemistry, Food and Drugs, and Industrial Microbiology.

THE NATURE AND IMPLICATIONS OF SCIENCE

A COURSE at the London University Extension Summer School at Wye College, Kent, July 27–August 10, intended for both scientist and non-scientist. Further particulars and application forms from the Deputy Director (Ext. D), Department of Extra-Mural Studies, Senate House, W.C.1.

FARADAY HOUSE ELECTRICAL ENGINEERING COLLEGE

A THREE-YEAR COURSE, commencing each term, in Electrical Engineering to qualify for Associate of Faraday House and Graduate of the Institution of Electrical Engineers, followed by one year's practical training in Industry to qualify for the Diploma of Faraday House. For Prospectus apply to Department "E", Faraday House Electrical Engineering College, 66 Southampton Row, London, W.C.1.

FOR SALE

"DISCOVERY" BOUND VOLUMES 1948–1955 inclusive and 1956 unbound. Also complete set of Penguin Science News. Offers to P. Graham, 101 Palmerston Road, London, N.22.

WANTED

POLARISING PRISMS in larger sizes, state dimensions—our offer by return. Rekab Instruments, 244 High Holborn, London, W.C.1.

MISCELLANEOUS

IF YOU ARE UNDER THIRTY

you could obtain a grant from the RATIONALIST PRESS ASSOCIATION to attend, free, the Six-day Congress of the International Humanist and Ethical Union, at Conway Hall, London, W.C.1, from July 26 to July 31. Lord Boyd Orr will preside. The grant would cover board, residence, admission to meetings, and travelling expenses up to £5. All you have to do is to write an essay of 1500 to 2000 words on "The Case For or Against Atomic Warfare" and submit it for approval by May 31.

Full particulars from Essays Officer, R.P.A., 40 Drury Lane, London, W.C.2.

Printed and Published in Great Britain by Jarrold & Sons Ltd, Norwich *Editorial Office: 244 High Holborn, W.C.1*

ovens. B
ead
elastic